Temperature Dominance over Human Life

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TEMPERATURE bears an importance to man far beyond the mere matter of his hour-to-hour comfort. In some places it lays a heavy, stagnating hand over his life and holds him to a vegetative existence; in others, it generates an energy and progressiveness which drives him forward with irresistible impetus. Its effects begin even before he is conceived, for the metabolic vigor of parental germ cells at the time of their union exerts a potent influence over the entire course of the new life. Without favorable temperatures, neither individual nor nation can develop innate potentialities to the full.

The hand of temperature is being felt over the world today, much as Ellsworth Huntington so ably pictured its course through past centuries. We are now caught in one of the long cycles of climatic change that alter the courses of nations and of world trends. Man thus has urgent need to understand the mechanism of this temperature dominance over him as an individual and over mankind as a whole. The answer lies in a close study of human dynamics.

The human body is essentially a combustion machine that functions only as its cells release energy by burning the foodstuffs taken in. True, this combustion in the cells is a very complicated affair, carried on at low temperatures and in numerous independent steps through the aid of special catalysts. Although it is far less violent than the gasoline explosions in an automobile motor, its over-all efficiency is no greater, and it is even more dependent upon rapid dissipation of its waste heat. The working efficiency of men, horses, and dogs ranges between 20 and 25 percent, but the Diesel engine designed by present-day engineers performs at over 40 percent efficiency.

For every unit of combustion energy transformed into work-output by our bodies, three or four similar units must be dissipated as waste heat. Failure of such dissipation to keep pace with heat production in the body may mean heat stroke and death within a few hours. The waste heat of combustion thus becomes one of the body's most important excretory products.

Sudden changes in external temperatures, or in the rate of heat production within the body, are quickly countered by the movement of more blood into, or away from, the skin and by the activity of the sweat glands. The body can thus meet short-term emergencies with only slight changes in its internal temperature or behavior characteristics. External heat or cold, prolonged through many weeks or months, however, induces basic and important changes in the body economy.

Following several weeks of difficulty in dissipating waste heat, physical and mental activity declines, and there is is a drop in the combustion rate. Some of the glands of internal secretion, which so largely influence combustion rate, go into a less active, or resting, state. This is particularly true with the thyroid, adrenal, and sex glands, probably also with the pituitary. A lowered total combustion rate means less energy for thought and action, as well as less waste heat to be dissipated. Physical and mental characteristics thus change, from the dynamic and pushing, to a more passive, "let-George-do-it" type. Personal initiative gives way to a desire for security.

That these are basic changes in the individual's metabolic make-up is evidenced by equally profound alterations in such body functions as growth, rate of development, resistance to infection, and thought capacity. When difficult heat-loss induces a lowered combustion rate in the cells, growth slows down and may be completely halted, even though an ample food supply be available; onset of puberty and maturity is progressively delayed, and ability to reproduce is reduced or completely obliterated, although matings go on freely; resistance to bacterial invasion is impaired, especially for those respiratory infections in which the white blood cells (phagocytes) provide the first and main line of the body's defense-system; and, finally, ability to solve problems is greatly impaired.

Proper ease of body heat-loss means just the opposite—a fast growing, early maturing, highly fertile individual, with a keen mentality and good ability to fight infectious disease. These statements are by no means hypothetical but are based upon well authenticated statistical findings on man and on experimental animals under controlled conditions. They show up in the laboratory, under natural climatic differences, and during the wide seasonal swings in middle temperate latitudes.

Half of the earth's population lives year after year under a depressive blanket of moist heat that makes

impossible an active life or high vitality. There children grow slowly, mature late, and are, in the main, of inferior stature. Although the birth rate is high because of lack of restraint, high stillbirth and infant mortality rates cut heavily into the ranks of those who might live on to adulthood. Infectious diseases are the chief causes of death at all ages. The menses come on 1½–2 years later than among girls of cooler climates, and reproductive fertility shows an even greater lag. The age-old fallacy of early tropical maturity should be abandoned—it probably represents a carry-over from the Ice Age of 20,000 years ago, when optimal temperatures for man were to be found only in what are now the tropical regions. Even two millenniums ago. Hippocrates was stressing the fallacy of early tropical maturity, although the girls of ancient Greece were beginning their menses at the same early age as in middle American latitudes today. With the subsequent rise in earth temperatures, the girls of Greece today begin their menses two years later than in Hippocrates' day.

Domestic livestock show a comparable retardation where heat-loss is difficult. To bring a steer to the choice 1000-pound slaughter-size takes 12–15 months in Iowa or Illinois, 2½–3 years in Louisiana, and 4–5 years in Cuba, Panama, or Colombia. This represents maximum adult size in the tropical heat, whereas in Iowa or Illinois the steer will grow to almost double this weight. Hogs show the same contrast, taking 15 months in Panama to reach the 200-pound slaughter size achieved by Iowa shoats in 6–7 months.

In spite of the lack of sexual restraint and our "Mother India" ideas of early tropical maturity, evidence indicates that functional fertility is attained several years later, on the average, among tropical girls than among the more lusty progeny of cooler climates. Laboratory findings under controlled temperature conditions provide complete confirmation of the human statistics. Difficulty in heat-loss can so reduce animal fertility that conceptions become impossible, even with oft-repeated matings. Human conceptions resulting in live births are also sharply reduced during prolonged periods of severe heat among people of the temperate regions. The whole state of Florida suffers a 30 ± percent decline in conceptions during the long summer heat, whereas in Maine conception rates then are highest.

The body's ability to resist or survive infectious attacks goes down with all other vital indices in tropical heat or in long subtropical summers. The number of deaths per 100 acute appendicitis cases hospitalized in the Gulf states is twice as high as in the Upper Plains states; and at Cincinnati, migrants from the South last just half as long with tuberculosis as do the Northern-born, considering only those who die, from first symptoms to death. Those adapted to heat also succumb more readily to pneumonia—a Dakota winter would produce a holocaust of pneumonia deaths in Panama or the Philippines!

Loss of mental acuity constitutes perhaps the most disturbing phase of heat effects, when viewed from the standpoint of the general welfare of mankind. Some years ago Ellsworth Huntington collected statistics showing best mental function at 38–40° F, whereas 64° F seemed optimal for physical performance. Today we know that college students, given the standard aptitude or intelligence tests at Cincinnati latitudes across the country, achieve ratings only 60 percent as high in summer heat as in winter cold. No such seasonal contrast in ratings occurs in the northern tier of states, where there is no prolonged depressive summer heat.

White rats have further confirmed the folly of summer sessions in colleges at lower latitudes unless the students be air-conditioned. With three groups of male rats from divided litters, kept on uniform diet and at three different environmental temperatures, it was found that ability to solve maze-tests was sharply retarded with increasing difficulty of heat-loss. The rats kept for four months at 55° F required only 12 trials before finding the correct maze pathway to the food dish; and, once they found the proper turns, no further errors were made on later testings. Those kept at 75° F made, on the average, 28 wrong turns before discovering the proper pathway, and even then their learning was far from complete. For the rats kept at 90° F, food seemed not worth the effort; those that did get through to the food took an average of 51 wrong turns and still could not repeat on successive days.

The rats' memory, or retention of learning, was tested by bringing them back to the maze after a month's absence. Those from the 55° F room showed perfect retention of their previous learning, those from the 75° F warmth had to relearn about half, but those from the 90° F heat seemed to retain no memory of their former efforts.

These basic observations on temperature dominance over mental ability and physical development are indeed of great significance to mankind as it faces existence problems in many regions of the earth. Should the more favored portions of our country give aid to those peoples whose living conditions are more adverse? Should such aid take the form of educational funds or of nutritional upbuilding? Fortunately, nutritional studies on animals have demonstrated that most of the depressive heat effects can be overcome by proper attention to vitamin and protein

intake. Certain of the B vitamins are needed in extra amounts, and hot-weather diets should be richer—not poorer—in protein, if we would avoid metabolic letdown. Actually, our protein requirement remains the same (in grams per pound of body weight) in heat and cold, but a lowered calorie intake in hot weather makes it necessary that the smaller amount of food eaten be richer in protein.

Difficulty in body heat-loss begins its dominance over any person's life even before he is conceived. The metabolic vigor of parental germ cells at the time of their union exerts a considerable influence over the whole life course of the new individual. Those children at Cincinnati latitudes whose parents have been depressed by July and August heat before conception have just half the likelihood of entering college that is enjoyed by those conceived in winter cold. Those conceived in summer heat also grow more slowly, develop later, and live a shorter life span (over four years less, according to Huntington's findings).

Further handicaps of hot-weather conception include a low likelihood of inclusion in *Who's Who* volumes and of being president of the United States of America. Eleven of our presidents were conceived in the first quarter of the year, ten in the second, *four* in the third, and seven in the fourth. Until the present incumbent entered the White House, there had never been an August conception at the head of our government. In any field of accomplishment one investigates, the advantages of cold-weather conception stand forth in bold relief. Perhaps these facts will find expression in high school or college eugenics courses and in planned parenthood through coming years. If so, the country's obstetricians will be able to plan a long vacation for each year!

Climatic temperature differences, whether brought about by latitude or altitude, are potent factors in human life, and so also are the wide seasonal temperature swings of the earth's middle latitudes. The fortunate nations of the earth are those located where the body's waste heat can be lost readily. Many other factors of life are also of great importance, of course, but this article is devoted to the basic role of temperature. Due recognition must be given to the part that improved nutrition may play in minimizing the depressive effects of external heat. Natural resources may thus exert a marked and beneficial effect on a given population group by making possible a better dietary intake, but dietary improvement will still be conditioned on the exercise of mass intelligence in food selection and on the willingness to work for the better food, no matter how great the natural resources. We thus come back to energy as the mainspring of life, with all its potentialities and handicaps.

Proper ease of body heat-loss may be essential to progressiveness and accomplishment, but its advantages are by no means free of hazards. Evidences of mental and physical breakdown are today most alarming in those regions of the earth where temperatures are most energizing. Arteriosclerosis and heart failure, diabetes, cancer, and many other breakdown diseases are there claiming far more victims than in tropical warmth, where infectious diseases run rampant. Northern rates of mental instability and breakdown, for instance, more than offset the decrease in tuberculosis deaths. Perhaps some day artificial conditioning will provide us with the Golden Mean.

Up through the millenniums since the last Ice Age, the crest of human civilization has shifted farther and farther poleward, with irregularly rising earth temperatures and melting ice caps. Improved housing and greater protection against winter cold have been considerable factors in this poleward shift, but probably of greater importance has been the expanding region of tropical heat. Volumes of argument pro and con would add little to that statement about the distant past, so let us move to more recent times.

Through the last 10,000 years of the earth's history, cyclic changes in temperatures have left fairly clear records. A millennium of rapidly receding glaciers and polar ice caps was succeeded by one of stability or advance. Five such cycles are in evidence over the last 10,000 years of rapid Ice Age regression. The next-to-last cold millennium fell in the days of early Greek and Roman glory and was followed by the thousand years of Dark Age warmth, when cereal grains could be ripened in Iceland and grapes in England.

The peak of Dark Age warmth occurred about A.D. 850, when optimal temperatures in far northern Scandinavia activated the Norsemen and Vikings into a century of exploration and settlement. The gradual return of benumbing cold to their homeland and to the Greenland and Iceland settlements from the tenth to the fourteenth centuries dimmed their glory. Central Europe was at the same time relieved of her enervating warmth and entered the Renaissance and the period of industrialization. The miracles of this Western mechanistic civilization have reached a peak in America during the century just passed.

Once again earth temperatures are surging irregularly upward, reaching levels in 1930 about as high as prevailed a thousand years earlier. During the warmth of the early thirties soil thawing in Greenland allowed excavation of Viking bodies that had lain in solidly frozen earth for a thousand years. All records available indicate that earth temperatures have been rising for a full century, bringing definitely milder

winters and the long summers of depressive heat that sap human energy and change the course of nations.

The same semitropical lethargy which earlier engulfed the Mediterranean countries of Europe is today creeping northward over the United States and Central Europe. Later onset of the menses in girls and smaller adult stature in American college youth have replaced the trend of recent centuries toward earlier maturity and ever-better physique. In the Carolinas the reversal came with children born in 1918, at Cincinnati latitudes a little later, and in Wisconsin it still remains only an indefinite hint. It is especially significant that this physical downturn should have occurred at a time when the production and distribution of foodstuffs were at all-time peaks and when greatest emphasis was being laid on child care and nutrition. Children now have fewer illnesses and grow faster in their early years than ever before; yet the adult stature is showing definite evidence of decline.

The northward shift of world power was emphasized by Germany's bid for a "place-in-the-sun" in World War I. Only the superior ingenuity and resources of Britain and America kept her from her goal, for Russia was then only in the early throes of her awakening, and France was quite incapable of coping with her more vigorous neighbor. When World War II came a quarter-century later, America was pushed to new peaks of industrial productivity and scientific advances that contributed substantially to victory, but the war's most significant outcome was the bid for world power by a new far-northern nation—Russia.

Retarded by the benumbing winter cold of past centuries, much of Russia today enjoys temperatures which are near the optimal for human endeavor. Freer flow of her energies and the heady successes of war and postwar years have given her a self-confidence that considers nothing impossible. Hers is now the early American frontier reaction of bubbling enthusiasm and nigh irresistible impetuosity. In the warm centuries ahead she may gain the sought-for place-in-the-sun, along with the lesser northern nations of Scandinavia and Canada. To appreciate that Russia is really a far-northern nation, one should bear in mind that the city of Stalingrad lies close to the latitude of Winnipeg.

The effects of temperature will go far beyond their present influence over individual life and national trends. The present millennium of warmth may witness complete melting of the polar ice caps and consequent profound changes in the climates of present polar and temperate zones. The earth has experienced long eons of freedom from polar cold during past periods of interglacial warmth, and Brooks, in his book, *Climate through the ages*, pictures the present ice caps as being down to the critically small diameter that makes them susceptible to rapid disappearance. Anyone desiring to make use of this information for long-term investment in northern real estate should buy high land, however, for the ocean level will rise roughly 150 feet as the ice caps disappear.

Present-day international interest in the mineral and fuel deposits of Antarctica may prove to be well based, in view of these temperature trends. Also, the broad, fertile, but still frozen reaches of northern Siberia and Canada may someday support the earth's most energetic populations, if the present outward expansion of semitropical lethargy continues. It takes only a few degrees of change in mean annual temperature to produce striking climatic alterations. Dark Age temperatures of Scandinavia, Britain, Iceland, and Greenland, for instance, were probably only 4–5 degrees higher than those prevailing through the colder centuries since the time of the Renaissance.

Much study and speculation have centered around the possible causes of these shifts in earth temperatures. The regular seasonal cycles are, of course, known to be based upon the changing inclination of the earth's axis with respect to the sun. Variations in sunspot activity and in the intensity of solar radiation to the earth have also been correlated with periods of unseasonal cold or warmth. Sudden outbursts of sunspot activity are accompanied by increased heat and magnetic radiation to the earth but are soon followed by greater storminess and low temperatures in temperate latitudes. During the declining or low phases of sunspot activity in the major 11-year cycles of the last two centuries, two thirds of the months have shown unseasonal warmth, while unseasonal cold has accompanied rising or high sunspot activity two thirds of the remaining time. We may tentatively accept the sunspots and the changes in solar radiation as a direct cause of weather shifts and of periods of unseasonable warmth and cold through the years. Whether the same influence lies behind the 2000-year cycles, and the Ice Ages and alternating Inter-Glacial Stages, still remains a matter of conjecture.

Sunspots are thus a matter of profound concern and have prompted investigations into the causes lying behind climatic fluctuations. As a result, we now know that each of the major planets of the solar system tends to depress sunspot activity on that part of the sun's surface exposed to a given planet. Observations have shown that sunspot activity decreases on any segment of the sun's face exposed to the earth during half of the sun's 28-day rotational period and increases on the opposite side during the other two weeks. Tides in the sun's gaseous mass have been

believed to result from the varying planetary pulls, but there is also a possibility that other heavenly bodies may also exert potent influences.

Our personal fortunes through the years, as well as our health and energy, are thus linked to the sun and, through it, to the planets of our solar system—and perhaps to the nearer stars!

Today we pride ourselves upon our scientific achievements and the conquest of disease by men of medicine; yet months or years of unseasonable warmth bring devastating economic downturns against which we have found no defense, and at such times sickness and death rates decline, even while our physicians are least busy. Statistically, one might say that people are better off the less they see of a doctor, but in reality, it is the lessened storminess and reduction in bodily stress that account for the health betterment in hard times.

Man is in reality a pawn of the environmental forces encompassing him, being pushed forward to a vantage point at one time or held in lethargic bondage at another. Here is a challenge of the first magnitude—can human intelligence find an effective answer? If not an answer, then it should at least comprehend the forces at work and the major significance of their effects.

Evidences of Associative Interference in Psychomotor Performance[1]

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UNEQUIVOCAL EXPERIMENTAL EVIDENCE of associative interference in the performance of a task predominantly motor in character was presented by Lewis (*4*) in a paper read at the 1947 meeting of the Midwestern Psychological Association. Lewis' subjects performed on a special model of the Mashburn apparatus built at Iowa. They first practised with the three controls in their usual setting. After attaining proficiency in the required task, they were given practice with all controls reversed. Following this reversed practice, they relearned the original task. Reliable decrements in performance appeared during the initial stages of relearning.

Buxton, in collaboration with Henry and Grant (*1*, *2*, *3*), had previously studied the effects of three different varieties of motor activity on acquired ability to perform on a Koerth-type pursuit rotor, but had found only *relative retroaction* and not actual decrements in ability to perform—decrements such as those easily demonstrated in verbal learning. In contrast to the decrements obtained by Lewis, Buxton could point only to amounts of gain in pursuit rotor performance following the interpolated activities which were different from the amount following a period of rest.

The Mashburn apparatus[2] in modified form seemed ideally suited to the studies of associative interference undertaken by Lewis. Basically, the unit consists of three double banks of small pilot lights and of a control stick and rudder bar. Each bank has a row of 13 red stimulus lights and a parallel row of 13 green response lights. Various combinations of stimulus lights come on automatically in random order, to provide patterns of red lights that must be matched by corresponding green lights. The three rows of green response lights are separately controlled by means of commutators and brushes associated with the stick and rudder bar. The green lights in any row come on and go off in succession as the corresponding control is moved in a given direction.

When a subject performs on the apparatus, he is presented with three randomly selected red lights, one in each of the three double banks. His task is to manipulate the stick and rudder bar until a green light is shining opposite each of the three red lights. When this condition prevails, a stepping relay oper-

[1] Studies of associative interference in psychomotor performance are being conducted at the State University of Iowa under Contract N5ori-57 with the Special Devices Center, Office of Naval Research.

[2] The apparatus was originally devised by Mashburn (*6*) for use in detecting flying aptitude. The Iowa model was constructed by Lewis for an investigation of the effects of noise and vibration on psychomotor responses (*5*). During the recent war, a somewhat improved form of Mashburn's original instrument was used extensively in the selection of air cadets and came to be known as the S. A. M. Complex Coordinator, a general description of which has been provided by Melton (*7*).

ates automatically to bring up a new combination of red lights. This matching procedure may be continued for desired lengths of time; and the score a subject makes is the number of three-way matches accomplished during a trial period.

As first constructed for the study of noise and vibration effects, the Iowa apparatus, like Mashburn's original, was arranged to simulate the controls in the old-fashioned airplane and to provide a maximum amount of eye-hand and eye-foot coordination. The green lights in the curved bank at the top came on in order from left to right as the stick was moved from left to right. Sidewise motions of the stick constituted the so-called aileron control. Green lights in the vertical bank came on successively from above downward as the stick was pushed forward. Forward-backward stick movements constituted the elevator control. Pushing the rudder bar (the rudder control) with the right foot lighted the green lights in the bottom row in succession from left to right.

The Iowa model of the apparatus was modified to provide, through a number of convenient switches, for a reversal of the correct movement of each control. It was thus possible for Lewis to have his subjects practise for specified numbers of trials with the controls all set in their normal positions and then practise with all of the controls reversed. The interpolated practice, that is, the reversed practice, could be followed by relearning of the original task to discover the effects of the reversed practice. As previously indicated, Lewis' study yielded clear evidence of associative interference—evidence in the form of absolute decrements in ability to perform.

The decrements in performance were unmistakable, but they seemed far less extensive than would have been expected from the amount of confusion displayed by the subjects during the initial stages of relearning. Every subject was observed to make many false moves and yet the decrease in the number of matches was in some cases only slight. It was necessary to conclude that number of matches, as a measure of performance, was not sensitive enough to reveal the full extent of the interference effects. To increase the sensitivity of the apparatus, methods were developed for recording the number of false moves made by a subject immediately after each new combination of stimulus lights was presented. The three controls had to be placed in certain precise positions in attaining each three-way match. As soon as a match was made, a new combination of red lights appeared. The subject could then move each control either correctly or incorrectly —in the direction of the stimulus light or away from it. A movement of a control away from a light was counted as an error. It was thus possible for a subject to make three errors on each match. Separate error counters were provided for the three controls. The number of errors made during each trial period became a measure of performance along with the number of matches. The errors made on each of the controls can be studied separately or combined with those for the other two controls to yield a total error count.

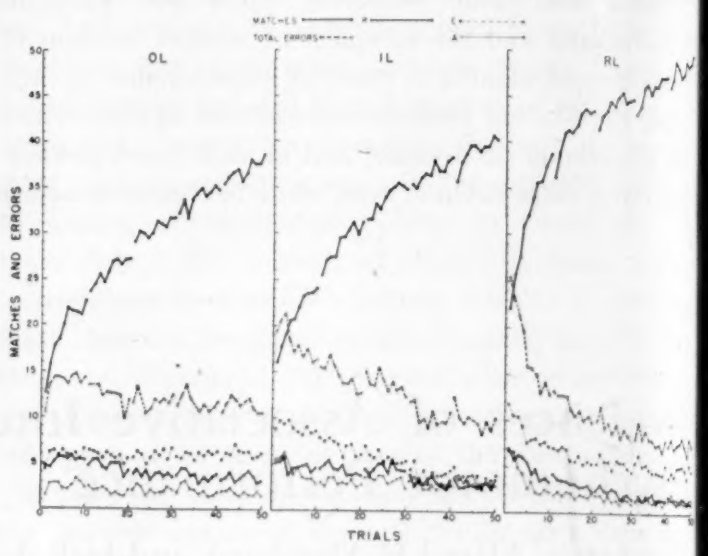

FIG. 1

The addition of the error counting procedure has added greatly to the usefulness of the Mashburn apparatus as a device for investigating associative interference.

As part of a rather extensive study of interference, eleven male students volunteered to take ten practice trials on the apparatus on each of 15 consecutive days. Each trial had a duration of two minutes. On each practice day, there was a rest period of two minutes between trials 5 and 6. All other trials were separated by a pause of 15 seconds. On the first five days (the first 50 trials), the subjects practised with the controls set in their normal positions. On the next five days (50 trials), the practising was done with the controls reversed. The original task was relearned on the last five days (50 trials).

The results for the eleven subjects are shown in Fig. 1, where mean number of matches and mean number of errors are both plotted as ordinates while trials are represented along the abscissa. There are separate plots for original learning, interpolated learning, and relearning. The upper curve in each case depicts the mean number of matches, while the heavy dashed curve (second from the top) shows total number of errors. The three lower curves are based on the mean number of errors made separately on the three controls, the control for each being indicated in the legend at the top of the figure.

During original learning, the mean performance of the subjects improved from 12.7 matches on trial 1 to 38.5 matches on trial 50. There was an initial in-

crease in total number of errors from 10.5 to 14.4, then a leveling off for a few trials, and finally a slight downward trend. Most of the decrease in errors occurred on the rudder control.

At the outset of the reversed practice (interpolated learning), the mean number of matches was 16.0. The facilitation was undoubtedly the result of positive

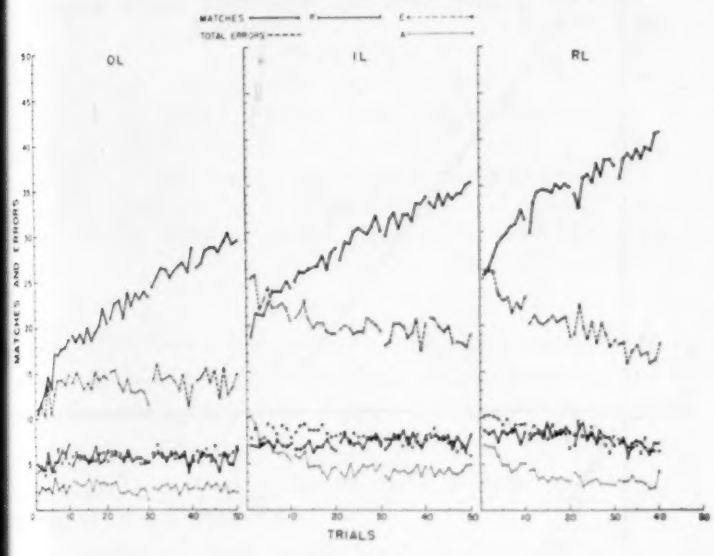

FIG. 2

transfer. Positive transfer in the task was to be expected because the subjects, during original learning, became familiar with the general requirements and with the way the controls were best manipulated. Associative interference was also to be expected. The combinations of stimulus lights were the same for original and interpolated learning, but exactly opposite movements of the controls had to be made in response to the lights. The error curves provide clear evidence of interference at the beginning of reversed practice.[3] (The mean number of errors on trial 3 was 21.4.) Mistakes on all three controls contributed to the increase in total errors, but the contribution made by false moves on the elevator control was greatest. The subjects all reported experiencing the greatest amount of difficulty with the elevator control. As shown by the curves, there was a general trend downward in total errors and in errors on the elevator control during interpolated learning.

At the outset of relearning, the mean number of matches was 22.0—a sharp reduction from the number on the last trials of original learning. The mean number of errors (25.3) was sharply increased. Mistakes were made on all of the controls, but the number made on the elevator was again conspicuously large. The decrease in number of matches and the increase in errors both pointed unmistakably to the functioning of associative interference. The interference effects were largely dissipated by the end of the first day of relearning, although remnants of them probably persisted into the third or fourth day. The reduced number of matches on the first and second trials of days 2, 3, and 4 of relearning may have arisen from lack of warm-up, but may have resulted in part from a recovery of interference effects during 24-hour periods without practice.

Evidences of associative interference similar to but less conspicuous than those displayed in Fig. 1 may be seen in Fig. 2, where results are presented for a group of nine male students given practise on 14 consecutive days[4] on the Mashburn apparatus with a different arrangement of the controls. On the Iowa model, it is possible to connect any one of the three controls to any one of the three banks of lights. When the data for Fig. 2 were collected, the rudder bar controlled the upper curve bank of green lights, while the aileron and elevator controls were associated with the vertical and horizontal banks, respectively. The resulting task was somewhat more difficult than the one arising with the standard arrangement of the controls. This greater difficulty was revealed not only by the smaller number of matches made after equal amounts of practice but also by a somewhat greater number of errors. The functioning of positive and negative effects at the outset of interpolated learning may be readily inferred from the data, and the functioning of associative interference during relearning is unmistakably revealed.

[3] Initial performance on the Mashburn apparatus with the controls reversed had been shown to be quite similar to initial performance with the controls in their normal position.

[4] Five days (50 trials) of original learning, five days (50 trials) of interpolated learning, and four days (40 trials) of relearning.

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TECHNICAL PAPERS

Ultraviolet Action Spectrum of T1 Bacteriophage

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T1 bacteriophage is a self-duplicating organism of remarkable stability. In the presence of a small amount of dried broth it can be maintained dry almost indefinitely. Advantage has already been taken of this to study the target size for deuteron inactivation (*5*). This target appears to be smaller than the whole bacteriophage particle. It is therefore of some interest to study the relative effectiveness of ultraviolet light in causing inactivation. Such studies have been made by Gates (*1*) on *S. aureus* bacteriophage and by Hollaender (in *3*) on various bacteria. A recent review of the significance of ultraviolet action spectra has been given by Loofbourow (*3*).

If the number of bacteriophage particles initially present is n_0 and after receiving an intensity I for a time t a number n survive then the relation

$$\frac{n}{n_0} = e^{-aIt}$$

holds where a is a constant for any one wavelength. This relation requires the random absorption of photons and applies only if the bacteriophage layer is uniform, the ultraviolet light is uniform, and there is no absorption by broth. Results indicate that if allowance is made for departure from these conditions, the relation is obeyed.

Our procedure has been to measure a for a series of wavelengths of light given by a quartz mercury arc and the resulting plot of a versus wavelength is the action spectrum.

Bacteriophage assays are made by plaque counts, the bacteriophage being mixed with *E. coli* and agar sufficiently warm to spread out on a Petri dish. The agar, coli, and bacteriophage mixture is then incubated at 25° C for about 8 hr and the plaques counted. We are indebted to Mrs. Marjorie Reaume for almost the whole of the preparation and plating work.

Selection of a particular wavelength was by means of a monochromator built according to a design by Harrison (*2*). It consists of an aluminized concave mirror placed at a slant under a water surface. A U-A2 uviarc is the principal light source used and the intensity of the emergent beam is monitored with a photocell which has been calibrated against a thermopile.

The results were compiled from seven runs, during which time some modifications of equipment and technique were made. The spectral dependence was found to be similar in spite of change of arcs, renewal of the mirror surface, and change of the amount of dried broth in which the bacteriophage was irradiated. Full energy calibration was only carried out in the last few runs.

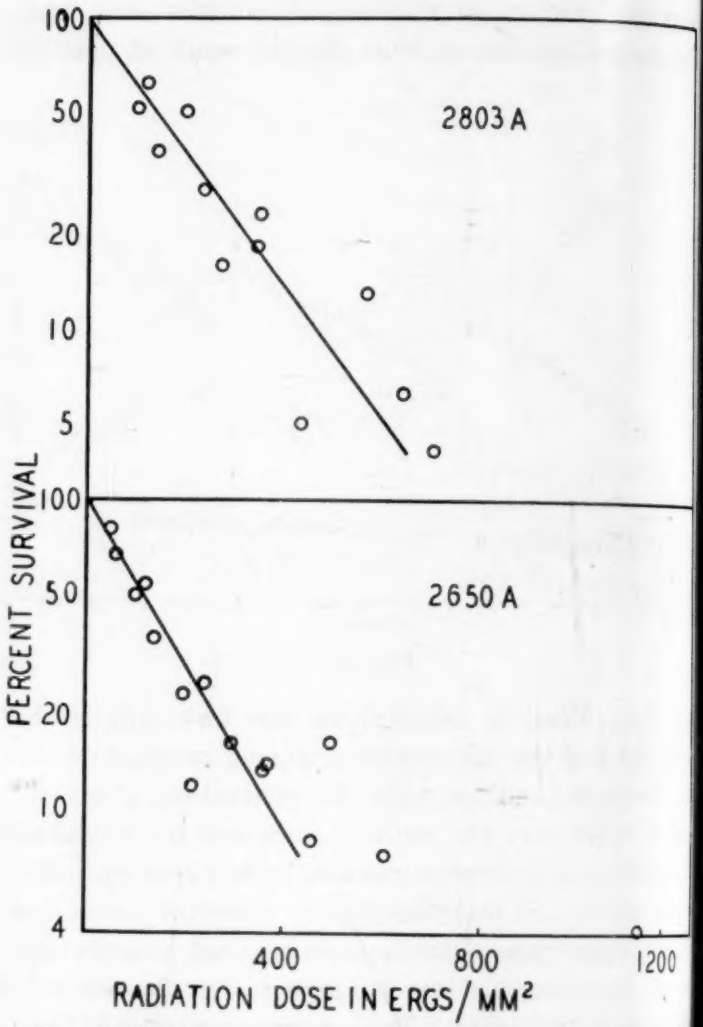

FIG. 1. Representative inactivation curves in which the logarithm of the percent survival is plotted against the radiation dose. The logarithmic relation holds over a factor of ten. At shorter wavelengths absorption in the broth, combined with sample inhomogeneity, causes a departure at high dose figures.

In order for a to be a valid indication of sensitivity, the rate of inactivation with energy dose must follow the relation given. Unless irradiation is at the same intensity for all wavelengths, the validity of doses as products of intensity and time must also be considered. Curves are shown in Fig. 1 for wavelengths 2650 A and 2803 A. Data are included for three runs, for which the intensity was varied over a factor of 2.5. Within the dispersion of the data, reciprocity of time and intensity appears to be acceptable. The dispersion for these runs is at least partly statistical, since control plaque counts were about 100. Treatment of the data as logarithmic also appears valid, at least to the 37% point at which a is determined. At longer wavelengths individual curves were even more accurately logarithmic.

At 2650 A and shorter wavelengths a positive curvature at lower survivals is noticeable. Decrease of the amount

[1] U. S. Public Health Fellow.

of broth on each irradiation strip from .05 to .01 ml reduced this curvature from 20 or 30% survival to below 10%. Absorption in the broth film is the most probable explanation, for although an absorbing film of uniform thickness would still give nearly logarithmic inactivation (*4*), we were not able to obtain consistently uniform broth layers. The difficulty of measurement and transfer of these small volumes is the most likely cause of the dispersion of the points on our inactivation curves.

TABLE 1

λ, A	3664	3131	2967	2894	2803	2760	
37% dose, ergs/mm²	~100,000	30,000	1200	750	220	224	
λ, A	2700	2650	2540	2482	2400	2350	2250
dose	207	185	232	455	523	327	690

The calibration of intensity in absolute units must be considered less accurate than the relative intensities of various wavelengths. The energy doses in ergs/mm² for reduction to 37% survival are shown in Table 1. The action spectrum plot is given with a calculated for It expressed in quanta/mm².

The results are very similar to those obtained by Gates. The features to note are the minimum at 2425 A, which is rather long in wavelength for desoxyribose nucleic acid, and the rather high inactivation at 2800 A. The value of a appears to fall at 2250 A, but this may be apparent and not real, since there can be heavy broth absorption. We do not believe that there is a sharp rise corresponding to protein absorption, however, as the broth absorption as estimated by rough measurements could hardly have exceeded a factor of two.

A comparison with work on bacteria as tabulated by Hollaender can be made. Our figure for the 10% dose at 2540 A is 535 ergs/mm². This shows that dried T1 bacteriophage is less susceptible at this wavelength than vegetative bacteria, but more so than spores.

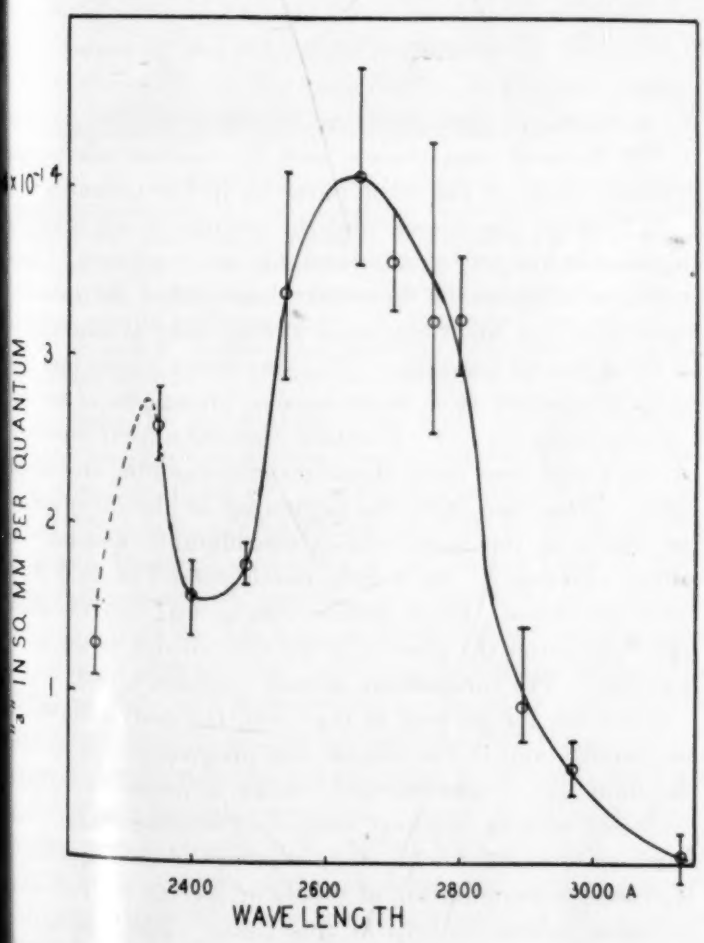

FIG. 2. Relative effectiveness of various wavelengths of ultraviolet light in causing inactivation of T1 bacteriophage.

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Lysis of Formalinized Bacteria by Bacteriophage

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Recently it has been pointed out (*1, 2*) that many lysed cells are found in mixtures of young and actively growing cultures of the B strain of *E. coli* with suspensions of certain bacteriophages when such mixtures are chilled and prepared for electron microscopy after very short incubation. After longer incubation stages in the development of new bacteriophage, particles are evident in such masses of lysed protoplasm. We have now found that the same phenomena of bacterial lysis and bacteriophage production are observed using bacteria previously inactivated with formaldehyde.

The bacteria used were 1 to 1½-hr cultures in tryptose broth. They were inactivated by being held for 15–30 min at room temperature after the addition of the desired volume of commercial formalin. Then the cells were washed once or twice by putting them in fresh broth and sedimenting them in a centrifuge. The washed suspension was made up to have a turbidity approximately that of the original culture. Effectiveness of the formalinization was tested in each instance by streaking a loop of this suspension on an agar plate and incubating. Such test plates remained completely free of bacterial growth when a concentration of 0.2% or higher of formaldehyde was employed; a few isolated colonies sometimes developed if the formaldehyde concentration was 0.04 or 0.08%. Such suspensions of killed, washed bacteria become clear on incubation following the addition of a suitable bacteriophage suspension containing enough particles to infect the bacteria present. Samples for electron microscopy were withdrawn after periods of incubation up to 1 hr, immediately chilled in ice water, and centrifuged cold, and the sediment was washed by successive centrifugations first from 0.5% formalin-saline and then from water-formalin. Final suspensions in a small volume were spread and dried in the usual formvar-covered grids and

metal-shadowed for electron microscope examination.

What was seen depended on the strength of the formaldehyde used for inactivation. At all concentrations up to the highest tried (1% formaldehyde = 2.5% formalin) there was the same picture of extensive cell rupture after short incubation that was observed with living bacteria. The masses of bacteriophage particles in the ruptured bacteria of many preparations further demonstrate beyond question that bacteriophage has proliferated during incubation with killed organisms. Electron microscopic evidence for such proliferation has been clear for both T2 and T4 bacteriophages; none could, on the contrary, be found in numerous experiments with T3 bacteriophage, though lysis evidently had occurred. The number of new bacteriophage particles depends obviously on the strength of the inactivating formaldehyde. As far as can be judged by electron microscopy, bacteria treated with 0.04% formaldehyde support as extensive bacteriophage multiplication as do living bacteria; the number of new particles appears diminished at concentrations above 0.2% formaldehyde and is greatly reduced and perhaps completely arrested at the highest concentration used (1%). It is also greatly lowered if the killed bacterial suspension is allowed to stand for several hours before the addition of infecting bacteriophage.

It has been instructive to determine by plaque counting the number of viable bacteriophage particles in these lysed suspensions of inactivated bacteria. They depend, even more strikingly, on formaldehyde concentration. With all but the minimal amount of formalin, the recoverable particles were far fewer than those added to bring about lysis, but after inactivation with 0.04% formaldehyde the yield often greatly exceeded the input. Thus in one experiment where suspensions containing 10^8 killed bacteria per ml were inoculated with approximately 10^6 particles of T4 per ml, the yield was reduced to about 0.01 the inoculum when the killing concentration of formaldehyde was 0.2%; it about equaled the inoculum when it was 0.08%; and it was about tenfold greater when it was 0.04%. Evidently the newly formed bacteriophage particles that the electron microscope shows developing from the more strongly formalinized bacteria either do not fully mature as independent infectious units or they are themselves gradually killed by the formalin-treated protoplasm which they have consumed.

Light on this point can be drawn from studies we made of the relative sensitivities of different bacteriophages to formaldehyde. These demonstrated, for instance that whereas the titer of a suspension of T2 or T4 was reduced to much less than 10^{-5} of its initial value by contact for 15 min with 0.2% formaldehyde, most particles in a suspension of T1 withstood 1.5% formaldehyde for at least one hour. Notwithstanding this remarkable resistance of T1 bacteriophage and its ability to lyse formalinized bacteria, its titer after such lysis was as dependent on the concentration of formalin used for bacterial killing as was that in the corresponding experiment with formalin-sensitive T2 or T4 bacteriophages..

These experiments on the development of particles of bacteriophage at the expense of bacteria that were inactivated by formalin have a direct bearing on the nature of this inactivation, as well as on the nature of bacteriophage and its mode of multiplication. They do not yet give a sufficient answer to any of these questions, but they definitely prove that certain bacteriophages can proliferate on bacteria that have been killed in the sense of having been rendered unable to develop into visible colonies. Other methods of experimentation will be required to show whether in this case bacteriophage is actually multiplying on already dead or on dying cells.

These studies are being extended to other circumstances of bacterial killing and will be reported elsewhere.

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Granulosis Disease in the Buckeye Caterpillar, *Junonia coenia* Hübner

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The first reported instance of a granulosis disease of an insect in the Western Hemisphere was that found occurring in the variegated cutworm, *Peridroma margaritosa* (Haw.), which was being reared in an insectary in California (*2*). In September 1948, several specimens of the buckeye caterpillar, *Junonia coenia* Hübner, collected near Westley, California, and brought into the laboratory were found to be infected with what also appeared to be a granulosis virus. This observation was confirmed by the microscopic demonstration of characteristic granules in the diseased host tissues, and by electron microscope demonstration of the virus particles in the granules.

In general, the disease and the accompanying granules in *Junonia* are very similar to those of *Peridroma*. Cross-infection experiments, however, showed that the two diseases were not identical, since neither host is susceptible to the virus of the other. The *Junonia* virus is also apparently distinct from those causing granuloses of several European insects (*3*). Diseased *Junonia* appear brownish in color and lose their characteristic metallic blue-black luster. The time from the beginning of the infection to the death of the insect varies considerably and may be rather prolonged. As a rule, death results in 6–12 days after infection. Dead larvae "hang up" on the food plant or die on the ground or on the bottom of the rearing cage. The integument usually remains intact.

When the integument is ruptured, the body fluid flows out rapidly and if the disease has progressed far enough the fluid has a characteristic milky appearance. When examined with an ordinary compound microscope the fluid was seen to be filled with large numbers of small granules. Microscopic examination of pieces of the fat body showed granules present in cells of this tissue. Electron micrographs of these materials showed the granules to be ovoid bodies about 350×500 mμ in size (Fig. 1A).

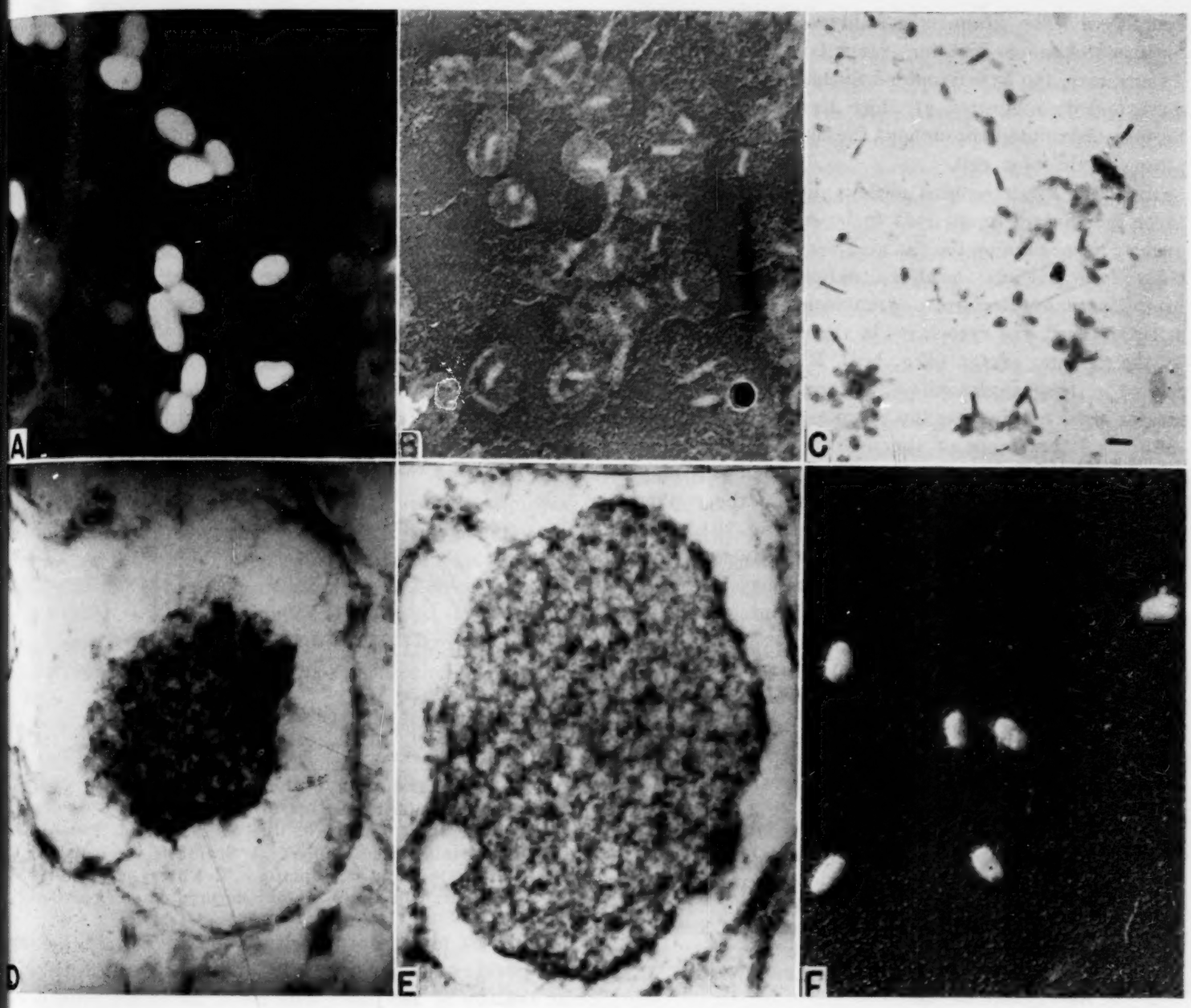

FIG. 1. A. Granules characteristic of the granulosis of the buckeye caterpillar, *Junonia coenia* Hübner. B. Granules partially dissolved in 0.05 M sodium carbonate solution, showing the location of virus particles, which are still covered with some of the granular material. C. Preparation in which the granular material has been completely dissolved, leaving the free rod-shaped virus particles. D. A single fat-tissue cell showing the nucleus slightly hypertrophied and beginning to disintegrate. The cytoplasmic area of the cell is occupied by large fat globules. E. Fat-tissue cell later in the disease, nucleus greatly hypertrophied. F. Granules from salt marsh caterpillar, *Estigmene acraea* (Drury), suffering from granulosis. A, B, C, and F, electron micrographs, magnifications approximately 10,000 ×; A, B, F, gold shadowed. D and E, ordinary photomicrographs, magnification approximately 1,100 ×. (Photographs by K. M. Hughes and H. B. Wasser.)

In order to demonstrate the virus particle enclosed within the granule, the same technique as that used with *Peridroma* granules (*4*) was applied here. With the use of Na_2CO_3 in a concentration of 0.05 M for 3 hr, the granules dissolved, revealing a rod-shaped virus particle enclosed within each granule, approximately 40×300 mμ in size. With certain preparations electron micrographs were made during the dissolving process, showing the virus particle still surrounded by some of the granule material. Such preparations indicate that the virus particle is freed from the granule simply by the dissolving away of the granular material. Working with the granulosis virus of *Cacoecia murinana* Hüb, Bergold (*1*) believed that in some cases, at least, the virus slips out of the particle when under the influence of the alkaline solvent. The writers have not observed such action with either the *Peridroma* or *Junonia* granuloses viruses.

Histopathological studies of diseased *Junonia* caterpillars showed the fat tissue to be the principal one affected by the disease, although at times other tissues such as the hypodermis and tracheal matrix were also involved. Sections of diseased larvae were fixed in Bouin's or in Carnoy's fixative and stained with iron hematoxylin or with Mallory's triple stain. In such preparations, the nuclei of the fat cells were prominently altered in appearance. As the infection progressed, the nuclei became hypertrophied, usually to a marked degree. The chromatin material of such nuclei underwent karyorrhexis and karyolysis and became diffused throughout the nuclear area. Granules, characteristic of the disease, seemed to be forming in the enlarging nuclei, and sometimes the greatly enlarged nuclei appeared to be liberating granules into the cytoplasm of the cell. At other times the nucleus appeared intact and yet some granules were present in the

cytoplasm. The granules possibly originate within the nucleus and sooner or later accumulate in the cytoplasm. At any rate, the hypertrophied nucleus eventually breaks down and disintegrates, at which time the granules may be seen distributed throughout the nucleoplasm and cytoplasm of the host cell.

Until the hypertrophied nucleus disintegrates it seems to be held intact or at least to be supported within the nuclear membrane by the fat globules pressing against all sides of the nucleus. Such a situation is not so apparent in the case of *Peridroma* granulosis. In the *Junonia* cells, however, the cytoplasm is almost entirely occupied by the globules of fat (Fig. 1, D, E) leaving very little room for the granules which, in the *Peridroma*, accumulate in large numbers in the cytoplasm of the cell.

In the later stages of the infection there seem to be fewer fat globules in the cytoplasm, which now may be fairly well filled with granules. Finally the cell membranes themselves break down, liberating the granules and other contents of the cells into the body cavity of the host insect. A few chromatin remnants may be seen scattered about in the almost completely disintegrated tissue. It is at this time that the insect dies.

Shortly after the *Junonia* granulosis was found, a similar infection was discovered in specimens of the salt-marsh caterpillar, *Estigmene acraea* (Drury) collected in Albany, California. Whether the disease is caused by the same or another virus is not yet known.

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A Filter Paper "Chromatopile"[1]

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The application of one- and two-dimensional paper chromatography to the separation of small amounts of many kinds of compounds has become a well-established and useful technique (*1, 2, 3, 5, 6*). In general these methods do not handle sufficiently large quantities of materials for isolation and chemical identification. Large columns of starch and other materials have been used satisfactorily for handling larger quantities of mixtures (*4*). Starch columns proved to be unsatisfactory, however, for isolation of certain substances under investigation in this laboratory. As a consequence, a new and simple apparatus and technique have been developed, using a pile of filter paper disks as the absorbing column.

[1] This work was supported by funds from the Rockefeller Foundation and from the Atomic Energy Commission administered through contract with the Office of Naval Research, U. S. Navy, Contract N6onr-244 Task Order V.

A diagrammatic sketch of a cross section of the column is shown in Fig. 1. It consists essentially of three parts:

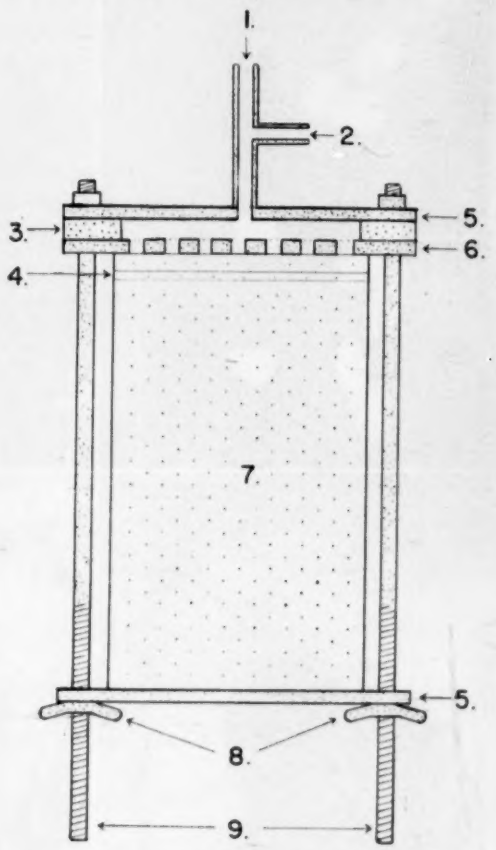

Fig. 1. Diagram of the filter paper pile column. 1. Connection for a rubber tube for filling the siphon. 2. Connection for the siphon tube. 3. Rubber gasket. 4. Filter paper disks containing the sample. 5. Stainless steel plates. 6. Perforated stainless steel plate. 7. Filter paper disk pile. 8. Wing nuts. 9. Bolts at four corners of steel plates.

the pile of filter paper itself (No. 7 in Fig. 1), a clamp for packing the paper tightly, and the solvent distributor at the top of the pile. The metal parts are constructed from stainless steel. The solvent distributor is connected by a siphon of rubber tubing to a 2-l flask containing about 1 l of solvent mixture. The flask is adjusted so that the level of the solvent is even with the top of the paper pile. In operation the column is placed upright on the ends of the clamp bolts in a 9 in. × 12 in. battery jar containing about 200 ml of solvent mixture. The jar is covered, with a hole left for the siphon tube.

The results of a trial run on known compounds will serve to illustrate the utility of the apparatus. Fifty mg each of adenine, tryptophane, phenylalanine, *p*-aminocinnamic acid, and anthranilic acid was dissolved in 20 ml of 0.1 N HCl and the solution was placed in the lid of a 100-mm Petri dish. Disks of 9-cm Whatman No. 1 filter paper were immersed in the solution, allowed to drain, and hung up to dry in air at room temperature. Twenty-five sheets were required to take up the solution and rinsings. To prepare for packing the column, the bottom plate of the clamp was removed and the clamp placed in an inverted position with the solvent distributor down. Forty filter paper disks (9 cm diam) were then placed carefully in the center of the perforated plate, followed by the 25 dried sheets containing the sample. The remainder of the column was made up of a pile of

8 packages of filter paper (9 cm, Whatman No. 1; total, 865 sheets). After careful alignment of the paper disks, the bottom plate of the clamp was placed on the pile and the wing nuts tightened as much as possible without mechanical aid. The column was then placed in the battery jar with the solvent distributor up. The distributor was then filled with the solvent mixture (3 parts *n*-butanol; 1 part *tert*-butanol and 1 part of 0.1 N HCl) with a pipette, and the siphon from the solvent container was connected and filled. After 28 hr the solvent front had descended 13.2 cm. The column was then removed from the jar and the pile taken out in sections. After the approximate locations of the five compounds had been determined by qualitative means, disks were taken 6, 10, or 20 at a time and extracted with hot 0.1 N HCl for adenine, tryptophane, and phenylalanine and hot 0.1 N NH_4OH for the remaining two compounds. Adenine, tryptophane, and *p*-aminocinnamic acid concentrations in the extracts were determined with the Beckman Spectrophotometer. Phenylalanine was determined colorimetrically with ninhydrin, and anthranilic acid fluorometrically with a Coleman Photofluorometer. The total recoveries of compounds from the column sections analyzed were: adenine, 41 mg; tryptophane, 46 mg; phenylalanine, 46 mg; *p*-aminocinnamic acid, 44 mg; and anthranilic acid, 46 mg. Thus, without considering losses in sheets removed for qualitative tests, 223 mg was recovered from the original 250 mg in the mixed sample. The distribution of the compounds on the column is shown in Fig. 2. As noted in the figure, the solvent traveled from the last sheet of the mixed sample through 730 filter paper disks or a distance of 11.8 cm. In the case of the sharpest peak (phenylalanine) more than 95% of the compound recovered was found in 36 filter paper disks representing a thickness of a little less than 6 mm. With such a degree of resolution it is clear that the solvent front movement is remarkably uniform in this type of column. Color tests made directly on sample disks showed a slightly more rapid movement of solvent at the edges, but the difference in rate is apparently negligible.

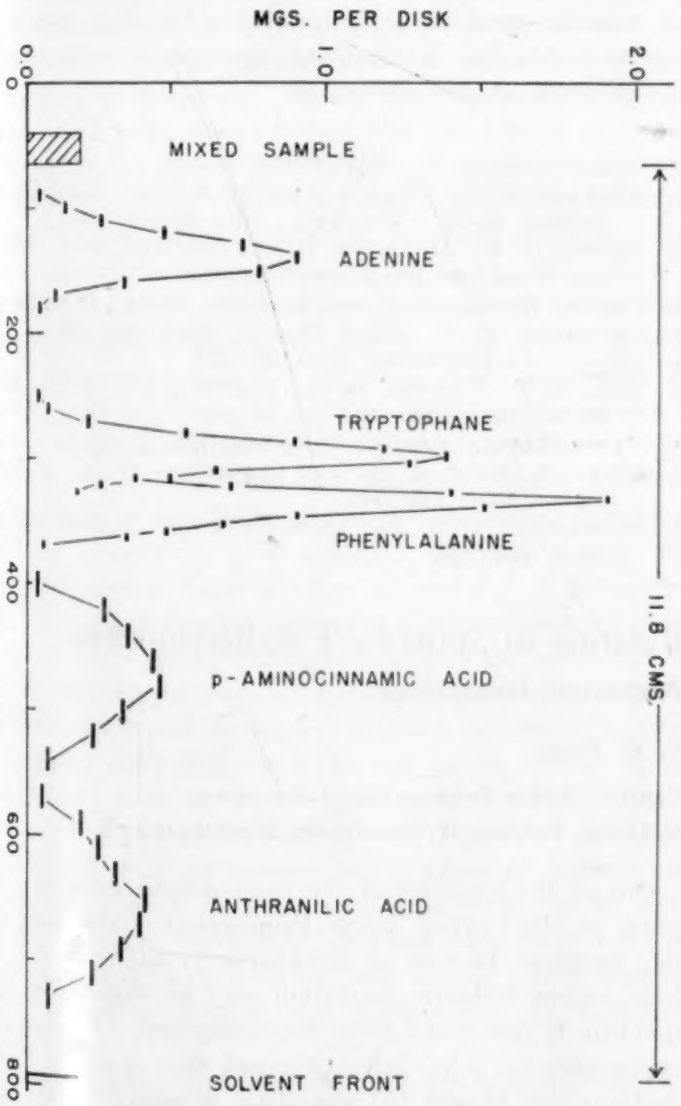

FIG. 2. Results of an experiment showing the separation of compounds of a known mixture. The length of the horizontal bars used for experimental points indicates the number of paper disks extracted for each analytical sample.

The simplicity and ease of operation of the filter paper pile column provides a practicable method for isolations without requiring complicated equipment. One feature which is most desirable is the ease with which a sample can be removed and incorporated into a new pile. Thus, a section of disks containing a desired compound can be taken out and placed in a new pile for use with a different solvent mixture.

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Tryptophane as an Intermediate in the Synthesis of Nicotinic Acid by Green Plants

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The paper by Beadle, Mitchell, and Nye (*2*) demonstrating that certain selections of *Neurospora* are able to synthesize nicotinic acid from tryptophane suggested to the writer that higher green plants might also have this ability, but only recently was it possible to set up such an experiment. That tryptophane is a precursor of nicotinic acid has now been quite conclusively demonstrated for a number of organisms. Nason (*7*) has very recently demonstrated that corn embryos are able to synthesize this vitamin when supplied with tryptophane and vitamin B_6. Several investigators have shown that animals can also use tryptophane in the synthesis of nicotinic acid (*6, 8, 9*), and there seemed to be no good reason why green plants could not do likewise.

[1] Paper No. 890 from the Department of Botany of the University of Michigan. This investigation has been aided financially by the U. S. Public Health Service, and some of the chemicals have been supplied by Merck and Co.

Leaves of cabbage, broccoli, and tomato plants grown in the greenhouse were used as plant material. The tryptophane was supplied to intact leaves through the petioles,

TABLE 1

SYNTHESIS OF NICOTINIC ACID BY GREEN PLANTS FROM TRYPTOPHANE*

Plant	Time in hr	Concentration of tryptophane in %			
		0	0.025	0.05	0.10
Broccoli ..	26	9.22		9.35	9.92
	47	8.18		8.53	
Cabbage ..	70	8.25	9.73	9.92	
	98	7.52	7.98		
	43	6.94		7.49	7.20
	47	6.65	8.25	7.81	7.43
Tomato ...	48	5.14	6.08		
	22	4.44	4.69		
	24	5.81	5.70	6.86	
	47	5.05	6.18	5.99	
	25	5.46	6.35	6.70	
	40	6.36	7.40	8.64	
	48	6.57	6.62	6.80	
	71	6.04			7.10
	48	5.18	6.12	7.60	7.64
	47	4.40	5.70	5.63	
	48	4.75	5.35	5.90	
	48	3.62		4.56	5.10

* The figures denote μg of vitamin/g of fresh plant material.

which were dipped into the solution. Nicotinic acid was determined by the microbiological method using *Lactobacillus arabinosus* as the test organism. The procedure as outlined in *Methods of vitamin assay* (*1*) was followed. The time allowed for synthesis to take place was usually about 48 hr, though longer and shorter periods were also used. Three days were too long, as the leaves wilted and the plants were not at their best; and usually more vitamin was obtained in two days than in one. Concentrations of DL-tryptophane ranged from 0.025 to 0.10 % L-tryptophane. These concentrations may seem a little high but since the experiments cannot be run very long it has seemed best to have high concentrations and get a high rate of nicotinic acid synthesis. No attempts have been made to study the relation between concentration of tryptophane and concentration of nicotinic acid obtained. Table 1 gives the results of these experiments.

TABLE 2

SYNTHESIS OF NICOTINIC ACID FROM TRYPTOPHANE BY GREEN PLANTS IN DARK AND IN LIGHT*

Plant	Concentration of tryptophane in %					
	in light			in dark		
	0	0.05	0.10	0	0.05	0.10
Tomato ..	3.64	4.56	5.10	3.26	3.93	4.71
	4.98	5.72	6.72	4.47	4.93	6.32
	6.07	6.67	6.83	4.65	5.06	5.76
Cabbage ..	6.94	7.49	7.20	6.25	6.69	6.96

* Figures denote μg of vitamin/g of fresh material.

While only a few experiments were done with broccoli and cabbage and there is not a constant increase in nicotinic acid assayed with increase in concentration of tryptophane supplied to the plants, there is, nevertheless, no doubt that the three plants used have synthesized nicotinic acid from tryptophane, which is all that the writer is attempting to show. The variation in amount of vitamin in different experiments is due, as has been pointed out (*4*), to differences in age of leaves used.

Another observation, which has nothing to do directly with nicotinic acid, should be recorded. When 4–5-in. tips of tomato plants with their young leaves were put in higher concentrations of tryptophane, the young immature leaves showed unmistakable signs of response to growth hormones. They curled up much as they would if the stem had been supplied with indoleacetic or butyric acid. They had evidently synthesized a growth hormone from tryptophane. This has been shown before but only under special circumstances.

The writer has previously shown (*5*) that light influences the synthesis of thiamin and riboflavin by green plants, and unpublished data indicate this may be true also for nicotinic acid. Experiments were therefore set up in dark and in light. Table 2 presents the findings.

Evidently light is not a factor in this synthesis. Recently Bonner (*3*) has outlined a scheme for the synthesis of nicotinic acid from anthranilic acid. He does not, however, state how anthranilic acid might be formed from the products of photosynthesis.

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Relation of Sporadic E Reflection and Meteoric Ionization

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One of the purposes of the radio-meteor research program at the Central Radio Propagation Laboratory of the National Bureau of Standards is to determine to what extent meteoric ionization may be responsible for sporadic E reflections from the ionosphere. Various investigators (*1, 3, 4*) have proposed that sporadic E reflections are caused by ionization produced in the atmosphere by meteors. Observations made up to the present time at this laboratory fail to support this view.

Since radio-meteor observations were begun at this

laboratory (*2*) special equipment for the purpose has been constructed and placed in regular operation. It consists of two transmitters and receivers operating on 27.2 and 40.98 mc/s emitting pulses with a peak power of 10 kw. Reflections of the pulses by meteor trails are displayed on a cathode-ray oscilloscope and simultaneously recorded on two recording milliammeters. The emitted pulses are approximately 50 microseconds in width and the pulse repetition rate is 60/sec. Duration of the sweep is adjustable to a maximum of 4 milliseconds. The antennas are half-wave horizontal dipoles spaced a quarter wavelength aboveground, thus directing the radiation predominantly upward in accordance with the well-known pattern of these antennas. Separate but similar antennas are used for emitting and receiving.

Multifrequency ionospheric records are obtained continuously at the Sterling, Virginia, station where the meteor equipment is installed. Sweeps over the frequency range 1–25 mc/s are made regularly every 15 min. The multifrequency transmitter's pulse width, pulse repetition rate, and peak power output to the antenna (but not necessarily its radiation therefrom) are approximately the same as for the meteor equipment. The antenna is a modified rhombic, oriented so that the main lobe is directed upward. Although no direct measurements of the antenna pattern have been made, it is known that the directivity of the antenna and its radiation efficiency change with frequency. At the lower frequencies this effect reduces the power radiated in the desired direction. Strong interference is encountered from other broadcasting stations in the frequency range between 1 and 2 mc/s. Because of this interference and the relatively poor radiation efficiency at these frequencies the receiver, which is not sharply tuned, often does not obtain reflections even from the normal ionosphere layers at the lower frequencies. The time required to sweep over the frequency range 1–25 mc/s was 15 sec during these observations.

On numerous occasions, the operation of the multifrequency ionospheric equipment has been visually observed while meteors were being recorded with the regular radio-meteor equipment. In general, no relation was observed between the occurrence of sporadic E reflections on the multifrequency equipment and reflections from meteor trails on the other apparatus. On certain occasions, however, records of reflections from the multifrequency equipment have been obtained coincident in time and range with reflections received on the meteor equipment and also, in some cases, with visually observed meteors. These reflections resemble sporadic E reflections, and could be so interpreted, although distinct differences between the two types of records can be seen.

An excellent illustration of these differences was obtained during the November 1948 Leonid meteor shower. The meteor equipment was in operation on both frequencies.

On the morning of November 15, 1948, at 0056 eastern standard time, a high intensity meteoric reflection was visually observed on the monitor oscilloscope, simultaneously on both frequencies at a distance of 125 km, continuing for 4 min on the lower frequency and for 2 min

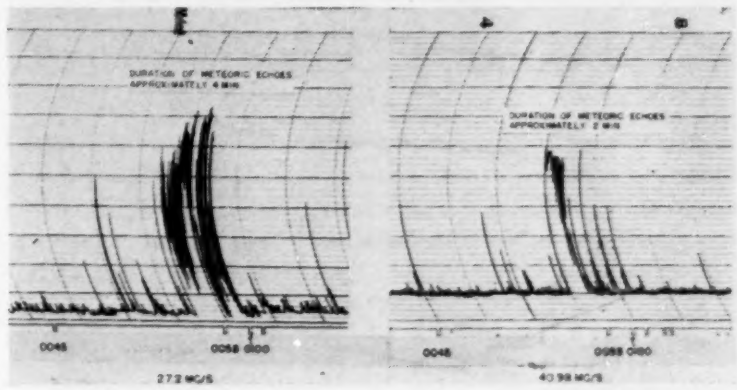

FIG. 1. Meteor record November 15, 1948.

on the higher frequency. At 0058 eastern standard time, the multifrequency equipment was turned on manually and showed, in addition to the regular F2 reflections, regular sporadic E reflections at a virtual height of 100 km which had been prevalent all night, and also another reflection at a virtual height of 125 km, which extended to a somewhat higher frequency. The appearance of this 125-km reflection, coincident with echoes seen at the same range on the meteor-recording equipment, seems to be sufficient evidence that what appeared as a layer at a height of 125 km was indeed the ionized trail of a meteor. These reflections varied considerably in intensity. It is to be noted that the echoes had already disappeared on 40.98 megacycles and were beginning to fade rapidly on 27.2 megacycles at the time the regular ionosphere recorder was turned on. Approximately 2 min later the ionosphere recorder came on automatically, making two consecutive sweeps, both of which showed sporadic E reflections at 100 km but neither of which showed the 125-km reflection which appeared earlier. A previous sweep, made at 0045 eastern standard time, showed faint sporadic E reflections at 100 km but nothing at 125 km.

Fig. 1 shows portions of the traces from the recording milliammeters on the two operating frequencies on which the record of the meteor appears. The pips on the lower margins are placed there automatically whenever the multifrequency ionosphere recorder is turned on. Fig. 2 is a reproduction of the photographic record made by the multifrequency equipment, (A) at 0045 eastern standard time, (B) at 0058 eastern standard time, showing the 125-km reflection attributed to the meteor trail just above sporadic E reflections from 100 km, and (C) at 0100 eastern standard time, at which time the 125-km reflection had almost entirely disappeared, although the sporadic E reflections were still present with considerable strength.

The meteoric reflection appearing in the E region of Fig. 2B resembles a sporadic E reflection in that there is no characteristic cusp indicating a critical frequency. However, comparison of this trace with that produced by the true sporadic E reflection shown in Figs. 2B and 2C shows that the meteoric reflections, though weaker, are also more sharply and clearly defined than the sporadic E reflections. The discontinuous character of the reflections, as a function of frequency, from the meteor

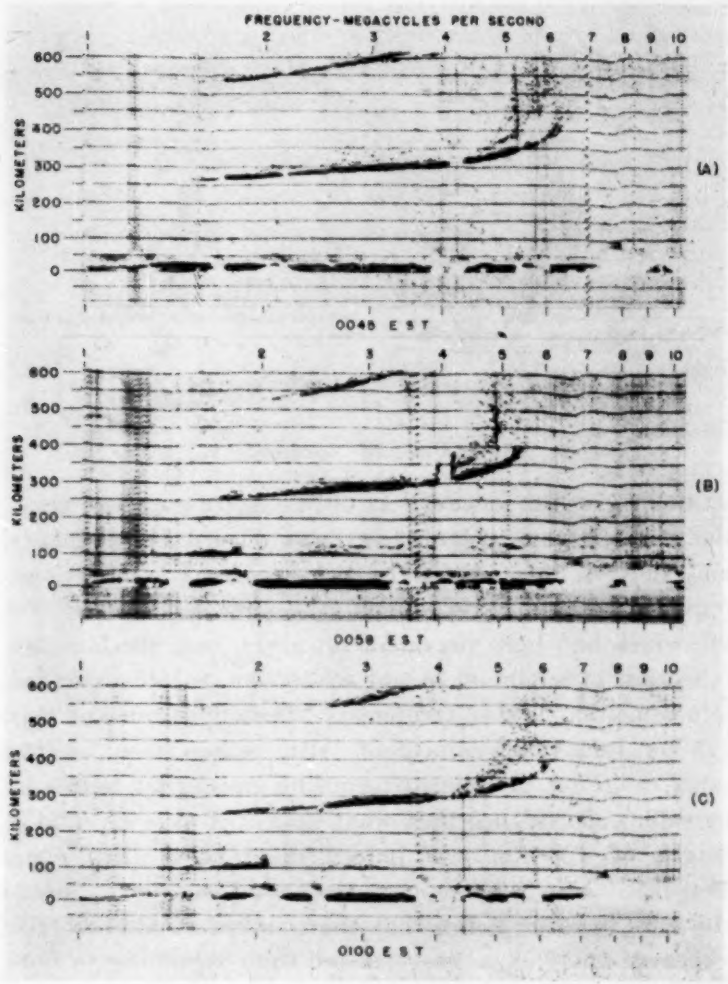

FIG. 2. Ionosphere recordings at Sterling, Virginia, on Nov. 15, 1948, showing sporadic E reflections at 100 km, and reflection from meteor trail (in B) at 125 km.

trail and the absence of reflections at lower frequencies are attributed to variations in antenna radiation with frequency previously described. It is presumed that in the absence of this and similar difficulties inherent in operation of automatic multifrequency equipment, reflections from the meteor trail would have been obtained even at the lowest frequency.

Since November 15, reflections on the multifrequency equipment produced by meteors have been frequently observed, often at times when true sporadic E reflections were entirely absent, as evidenced by continuous sweeps of the multifrequency recorder covering the period prior to the appearance of reflections on the meteor equipment and carried on through until their disappearance. Records obtained on the night of December 12, 1948, are shown in Fig. 3. In this case true sporadic E reflections were obtained from a height of 100 km and a meteoric reflection shown in Fig. 3B at approximately 80 km. The records of Fig. 4 were made on December 13, 1948, at a time when no sporadic E was present. In both cases the multifrequency equipment was turned on by the operator at the appearance of strong reflections on the meteor equipment. In both cases the reflections attributed to the meteors were from an apparent height agreeing with the range observed for the meteors.

An examination of the photographs of Fig. 3 reveals several interesting characteristics of meteoric reflections in comparison with those from sporadic E. The sharp definition of the meteor trace previously mentioned is again demonstrated. Also noticeable is the fact that the sporadic E reflections begin to appear at a lower frequency than those from the meteor. This effect is probably due to the radiation pattern of the antenna used with the multifrequency equipment previously described and the comparatively small target area presented by the meteor trail. Another feature of Fig. 3B is the appearance of two M reflections. At the frequency of 3 mc/s, used as a convenient reference abscissa, one sees a reflection at 375 km, which corresponds to the M reflection involving the sporadic E reflection as seen in Fig. 3A at about 100 km, and another at 415 km, which is attributed to the meteor.

In this second case the simple relationship, 2F minus height of meteor, would indicate a height of only 55 km for a meteor directly overhead. The implication is that the meteor was to one side of the observing location at a slant range equal to the 80-km direct reflection but at a somewhat lower true height. In this case the simple relationship, 2F minus height of meteor, does not yield the apparent height of the M reflection involving the meteor trail, indicating that the meteor reflections were not from a point directly overhead, and that the true height of the meteor was somewhat less than indicated by the direct reflection.

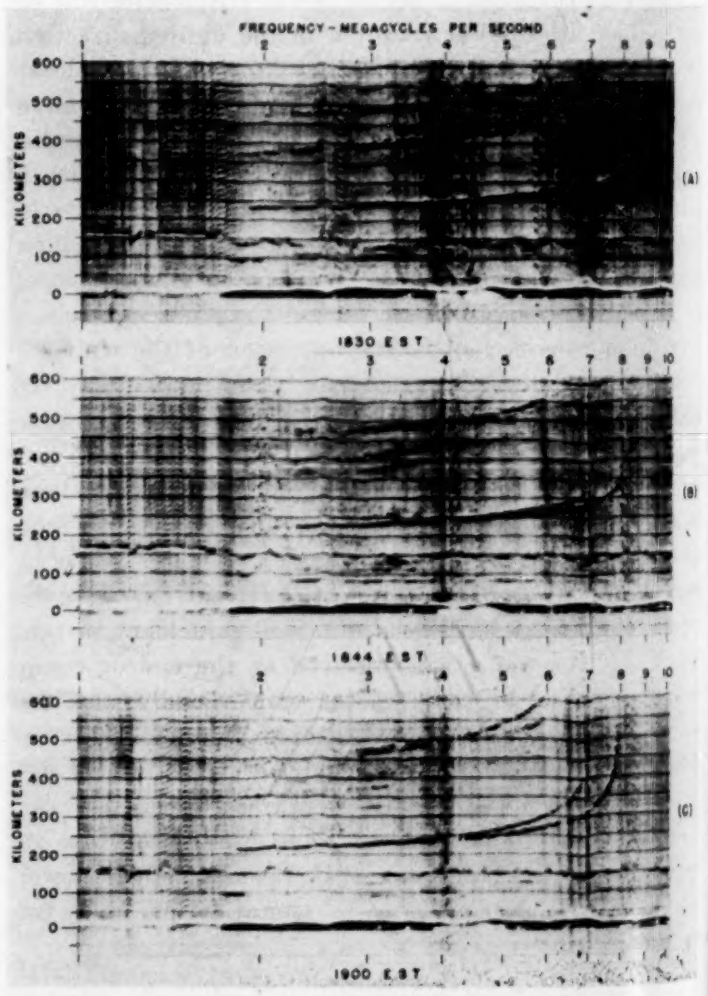

FIG. 3. Ionosphere recordings at Sterling, Virginia, Dec. 12, 1948, showing sporadic E reflections at 100 km, and reflection from meteor trail (in B) at 80 km. (Simulated reflections at 150 km caused by synchronous interference.)

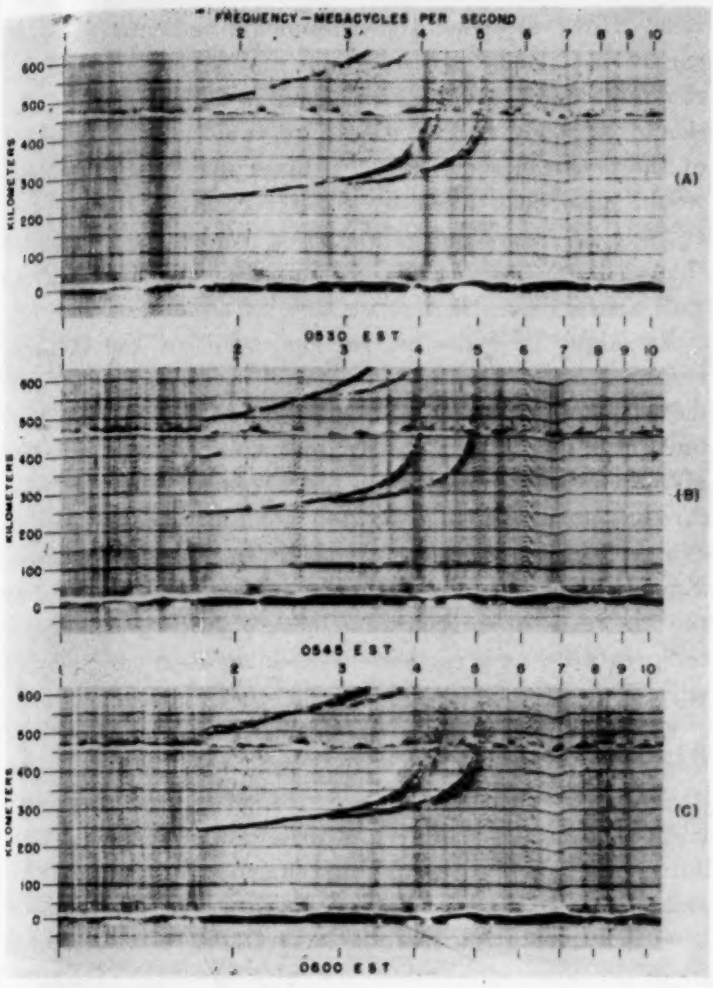

FIG. 4. Ionosphere recordings at Sterling, Virginia, Dec. 13, 1948, showing no sporadic E reflection but reflection from meteor trail (in B) at 105 km. (Simulated reflections at 470 km caused by synchronous interference.)

Fig. 4 is similar to Fig. 3 except that the records shown were made at a time when sporadic E was not present, and the meteoric reflection could be erroneously interpreted as a sporadic E reflection.

It has been found that the relative polarization of the antenna used with the ionosphere set and those used with the meteor equipment makes little or no difference at these frequencies. Coincidences of the type described occur when the orientation is such that the electric vectors are mutually perpendicular as often as when they are parallel.

Although it is beyond the scope of this note to go into an involved discussion of the relation of sporadic E reflections and meteoric ionization, it has been shown that reflections are obtained from meteoric ionization which can be distinguished from sporadic E reflections. A preliminary statistical examination, now under way, of a large quantity of data obtained over several months of nearly continuous observation does not appear to show that variations in meteoric activity are associated with corresponding variations in occurrence of sporadic E reflections. Continued observation of meteoric activity and perhaps a new line of approach in the technique of obtaining and evaluating the data are necessary before more extended conclusions can be drawn.

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Comments and Communications

The Betatron Building and Installation at the University of Saskatchewan

About two years ago the authors, all members of the staff of the Department of Physics at the University of Saskatchewan, felt that in order to carry out a significant research in nuclear physics they should act together as a team for the purpose of obtaining and using a 25-Mev betatron. The group was interested in investigating also its possible therapeutic uses in the treatment of cancer. Because of their wide interests they were able to enlist the generous support of the Atomic Energy Control Board of Canada in the purchase of the instrument and of the Provincial Government of Saskatchewan in the erection of the building to house it. Auxiliary equipment has been obtained through the support of the university, the National Research Council of Canada, the National Cancer Institute, and local cancer societies. The machine will be used both as an X-ray machine and as an electron beam machine. It is available to other groups in the university who may wish to investigate the biological and the chemical effects of high energy radiations.

The betatron building was built in one angle of the T of the main building but separated from it by 11 ft. It has the same floor level and is connected to the main building. The principal research rooms and instrument shop facilities of the main building are thereby made directly accessible to the betatron building, yet the betatron itself, a source of highly penetrating radiation, is well removed from persons in the main building. Its beam is directed away from the main building and is well below ground level.

The general plan of the betatron building, presented in Fig. 1, shows that the betatron room is surrounded by heavy concrete walls. The wall in the direct path of the X-ray beam is seven feet thick. In place of having a direct opening and a necessarily massive door between this room and the control room, entrance is made through a corridor long enough to reduce scattered radiation to a tolerable level. This corridor is entered from the control room through a doorway which is closed by a light, soundproof and airtight door. In spite of the greater walking

distance between the control panel and the betatron room, experience has shown that this plan is very satisfactory.

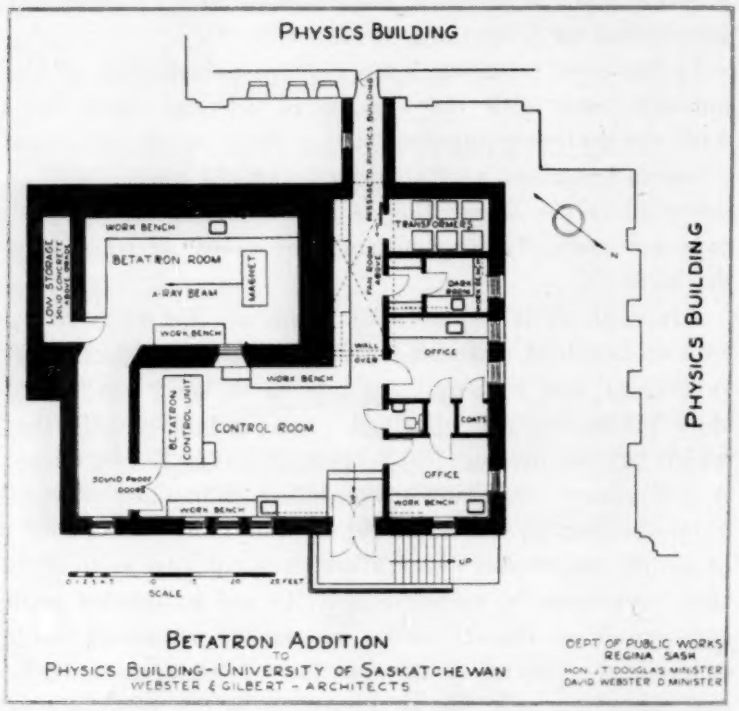

FIG. 1. General plan of the betatron building.

The betatron room is supplied with an overhead *I* beam with a chain block for lifting heavy equipment and moving it along a line normal to the front plane of the betatron and in line with the beam. Beneath this *I* beam are two steel rails on which a heavy truck with flanged wheels may be rolled. These rails and a closely adjacent steel scale of equal length are flush with the floor. Thus heavy equipment can be placed quickly at any point in front of the betatron and its position recorded. The work benches extending along each side and across the end of the room are fully equipped and have closed cupboards beneath them. The betatron itself rests on a concrete pier which extends 4 ft into the ground and is sufficiently distant from the rear wall to give room for the manipulation of air-pumping outfits which will be needed when donuts requiring continuous evacuation are used.

The control room contains, in addition to the usual laboratory benches, the large control unit. Between this room and the betatron room proper is a triple-glazed window, so placed that the operator at the control cabinet can see a large mirror mounted near the ceiling in the betatron room. This mirror can be rotated by the operator about either or both of two axes arranged so that he can constantly view the object or person being irradiated. Four large conduits inclined upwards at 45° from the betatron room make it possible to run experimental conductors from one side of the wall to the other without allowing any bundle of radiation to strike persons in the control room.

Four small rooms are provided. The transformer room is closed by a heavy fire- and sound-proof door. It contains three tripling transformers, three step-down transformers, and one 110-v service transformer. The photographic dark room is of the usual design. The remaining two rooms are similar and are equipped as small laboratories. However, should developments indicate the need, each with its small dressing room may serve as a reception room for patients. A washroom is included. Mention should be made also of a storage vault at the outer end of the betatron room, which utilizes space that otherwise would have been filled by concrete. Since the vault is entirely below ground level, 7 ft of concrete is not needed there for the absorption of radiation, as it is in the wall above.

As might be expected, the operation of the betatron results in the release of considerable heat energy. To remove this, a properly equipped fan room, not shown, is built over the hallway. Its blower discharges air into the airtight betatron room, forcing the air from that room through an acoustically-treated conduit into the control cabinet, which contains a large bank of condensers. From there it escapes either from the building or into the fan room to be recirculated, according to the outdoor temperature—an arrangement made necessary by the wide variations in temperature characteristic of our climate.

Fluorescent lighting is used throughout. All ceilings, the upper halves of the walls in the betatron room, and its entrance corridor are covered with Acousti-Celotex tile. A betatron usually has an objectionably loud hum, but it is found that the use of so much acoustical material and the L form of the room combine to reduce the noise level in the betatron room to 92 decibels. In the control room the hum is certainly not objectionable—its intensity there is only 54 decibels, a common level in offices. In the other rooms it is even lower.

TABLE 1

RADIATION RECEIVED DURING AN 8-HOUR DAY*

In line with the X-ray beam at ground level outside the building	0.02 r
Maximum observed on the roof of the building and above the axis of the X-ray beam	0.40 r
Near the door between the control room and the corridor leading to the betatron room:	
Control room side	0.06 r
Corridor side	0.25 r
In the corridor leading to the betatron room near the entrance to the betatron room proper	1.0 r
At the control panel in the control room	0.05 r
In the small laboratories	0.02 r
Directly behind the betatron in the hallway	0.10 r
In the dark room	0.05 r

* Betatron operating at 24 Mev and giving an output of 100 r/min at 3 ft.

The laboratory circuits distribute both a-c and d-c power, and include also storage battery lines. In the betatron room a special circuit makes it possible to block the operation of the betatron at three different points. A warning horn signal is automatically sounded 5 sec before voltage is applied to the magnet, thus giving any person working in the room ample time either to block the operation or to get out of the room. The uninsulated 16,000-v terminals on the back of the betatron are sufficiently dangerous to warrant these precautions. The corridor offers an easy and quick escape from radiation

which would not have been possible had a heavy door been used instead.

Stray radiation at various points was measured by a Victoreen radiation meter, both inside and outside the building, and the results are recorded in Table 1.

It will be seen that the building affords adequate protection to everyone having to do with the betatron. When it is realized that the betatron will seldom, if ever, be operated continually for an 8-hr day the actual radiation likely to be received by any person is considerably smaller that that indicated in Table 1. The background count of a counter inside a lead castle situation in the main physics building is not affected by the operation of the betatron, although the background inside the betatron building is affected.

The betatron was manufactured by Allis-Chalmers Company of Milwaukee, Wisconsin, under the direction of Dane Scag. The machine is very similar to the one being used by the betatron group under D. W. Kerst at the University of Illinois. The machine is provided with four elevator screws simultaneously operated by a single motor to raise the upper yoke of the magnet. This greatly facilitates the replacement of donuts. The poles of the magnet are made of oriented steel and the field is adjusted for azimuthal uniformity by package coils. The machine is provided with a monitor which records the instantaneous intensity of radiation with auxiliary circuits to integrate this intensity. After a prearranged dose in roentgens has been given the machine automatically shuts itself off. The condensers for the tuning of the betatron are all located in the control unit.

The betatron, as installed, could operate only at an energy of about 25 Mev but it is being altered to operate through a range of energy levels below this value. An integrator circuit is being constructed to maintain any energy setting of the betatron to an accuracy of 0.1 percent. This will be accomplished by causing expansion of the electronic orbit to occur when the magnetic flux reaches a predetermined value. The machine will then operate at this energy or flux regardless of line voltage fluctuations or frequency changes. For constant voltage input to the betatron building, the magnetic flux is constant to within ± 2 percent as the frequency varies from 59.7 to 60.3 cycles per second.

The group working with the betatron plans to do experimental work in the field of nuclear physics. Some of the problems which will be attacked first include the measurement of the threshold energy for photodisintegration for (γ, p) and (γ, n) reactions in which the product of the reaction is not radioactive. This means that it will be necessary to detect the protons or neutrons produced in the reaction. Other problems involve the measurement of the energy distribution in the betatron spectrum so that the actual cross sections for photodisintegration may be measured.

For the investigation of the therapeutic applications of the betatron a d-c amplifier in conjunction with a small probe ionization chamber has been constructed. This will be used to measure the distribution of radiation within a water phantom. This distribution will be measured for a series of sizes of fields and for different types of step filters in an effort to get a clinically useful distribution. After this has been accomplished the machine may be used for cancer therapy. Many interesting experiments using the electron beam have been tentatively planned. These, however, must await the successful development of pumping techniques for use with electron donuts which have been obtained from the University of Illinois.

The authors would like to take this opportunity to thank those who have helped them to obtain the betatron and its building and auxiliary equipment in such a short time. In particular they wish to express their appreciation to D. W. Kerst and his associates, of the University of Illinois, who made available to them the facilities of their laboratory and who gave generously much valuable information and advice.

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H. E. Johns, and L. Katz
University of Saskatchewan

Note on the Origin of Cosmic Rays[1]

W. Baade and F. Zwicky (*Phys. Rev.*, 1934, **45**, 138 and **46**, 76), F. Cernuschi (*Phys. Rev.*, 1939, **56**, 120), and F. Hoyle (*Monthly Notices R.A.S.*, 1946, **106**, 384) have suggested that supernovae might be responsible for cosmic rays. Hoyle has recently considered this idea more closely in connection with his ideas about the origin of the chemical elements (*ibid.*, p. 343). He suggests that the heavy nuclei, or, better, the nuclear lumps, which are expelled during the supernova outburst might lose their accompanying electrons and thus become surrounded by strong electric fields in which nuclei might be accelerated up to energies as high as the largest energies found in cosmic rays. As a point in favor of this theory, Hoyle points out that, assuming that the average supernova will produce 0.1 M_0c^2 (M_0: solar mass; c: the velocity of light) energy in the form of cosmic rays, the density of extragalactic nebulae and the frequency of supernova outbursts are such that one can just explain the observed density of cosmic rays observed on the earth.

However, H. Alfvén (*Z. Physik*, 1937, **107**, 579) has pointed out that a galactic magnetic field of only 10^{-13} gauss would be sufficient to keep all cosmic rays inside our galaxy, and L. Spitzer, Jr. (*Phys. Rev.*, 1946, **70**, 777) has given strong arguments for the existence of such a galactic field. This means that we have to consider only our own galaxy as far as the production of cosmic rays is concerned. If we again assume that supernova outbursts are responsible for cosmic rays, we now have to estimate how large a density of cosmic rays we can expect. Assuming the production of cosmic ray energy per supernova to be about 0.001 M_0c^2 (Hoyle's estimate seems to us to be rather high, and we shall see that even a ten times smaller estimate would have been sufficient in order to get agreement between the observed and estimated energy densities), and assuming one supernova out-

[1] This letter was written while the author was temporarily at Yerkes Observatory, Williams Bay, Wisconsin.

burst per 500 years per galaxy (Zwicky, F. *Astrophys. J.*, 1942, **96**, 28), the energy produced per sec per galaxy is about 10^{41} erg. According to R. D. Richtmyer and E. Teller (*Phys. Rev.*, 1949, **75**, 1729), the lifetime of a cosmic ray in our galaxy is about 50 million years. Assuming the volume of our galaxy to be about 10^{12} cubic parsec ($\approx 3.10^{67}$ cm^3), the total cosmic ray density in our galaxy should be about 10^{-11} erg cm^{-3}. This is of the same order of magnitude as the value of about 5.10^{-13} erg cm^{-3} obtained by Richtmyer and Teller from B. Rossi's data (*Rev. mod. Phys.*, 1948, **20**, 537.).

As far as the production of the high energy particles in the supernova outburst is concerned, we favor a mechanism different from that suggested by Hoyle, but essentially the same as that proposed by Cernuschi. Cernuschi proposed the fission of the nuclear lumps as the mechanism and made some estimates of the available energy per fission fragment on the basis of a very crude model of the nucleus. At present, we have a better understanding and knowledge of the energy which can be released in a fission process of a nuclear lump. Also it seems to us that the primary cosmic rays should not be the fission fragments but the neutrons accompanying the fission. For an estimate of the energy which becomes available at a fission process, we shall use N. Bohr and J. A. Wheeler's expression (*Phys. Rev.*, 1939, **56**, 426) for the packing constant (i.e., the energy content per unit mass)[2] of a nucleus of charge Z and atomic weight A in the form given by G. B. van Albada (*Astrophys. J.*, 1947, **105**, 393):

$$f = \alpha y^2 + \beta y - \gamma + kZ^2A^{-4/3} + sA^{-1/3}, \qquad (1)$$

where f is the packing constant and

$$\left.\begin{aligned} y &= (\tfrac{1}{2}A - Z)/A, k = 0.63\ mMU, s = 15\ mMU \\ \alpha &= 83\ mMU, \beta = 0.81\ mMU, \gamma = 6.65\ mMU. \end{aligned}\right\} \qquad (2)$$

From van Albada's considerations of equilibria at zero temperature and high densities, it follows that the specific charge of the nuclear lumps ejected by the supernova will be in the neighborhood of 1/4:

$$Z/A \sim 1/4. \qquad (3)$$

Using equations (2) and (3), equation (1) takes the form:

$$f = -1.3 + 0.04\ A^{2/3} + 15\ A^{1/3}\ mMU \qquad (4)$$

and the energy content of the nuclear lump is given by:

$$E = Af = -1.3\ A + 0.04\ A^{5/3} + 15\ A^{2/3}\ mMU \qquad (5)$$

In Table 1 we have collected the values of f in mMU, and E in mMU and in ev for different values of A.

It is immediately seen from Table 1 that the fission of nuclear lumps with A equal to or larger than 10^5 will produce energies of the order of the highest observed cosmic ray energies.

The present note must not be taken too seriously, but there are a few points that might be well worth looking into. The first one is the fact that the primary cosmic rays contain about 30% nuclei with Z between 2 and 26 (see, e.g., Bradt, H. L., and Peters, B. *Phys. Rev.*, 1948, **74**, 1828 and 1949, **76**, 156). This can partly be due to the ejection of these nuclei with energies of the order of magnitude of their rest energy by the supernova during the outbrust (cf. Hoyle, *Monthly Notices R.A.S.*, 1946, **106**, 384), or partly due to possible tripartitions. Experiments with uranium (Tsien, S. T. *et al. J. Phys. Rad*, 1947, **8**, 165 and 200; see also Titterton, E. W., and Goward, F. K. *Phys. Rev.*, 1949, **76**, 142, and Lark-Horovitz, K., and Schreiber, R. E. *Phys. Rev.*, 1941, 60, No. 2, 156) indicate that one tripartition occurs against

TABLE 1

A	f in mMU	E in mMU	E in ev
100	2.9	300	$3 \cdot 10^{8}$
200	2.7	500	$5 \cdot 10^{8}$
300	2.8	800	$8 \cdot 10^{8}$
500	3.2	1,600	$2 \cdot 10^{9}$
1,000	4.2	4,000	$4 \cdot 10^{9}$
5,000	12	$6 \cdot 10^{4}$	$5 \cdot 10^{10}$
10,000	18	$2 \cdot 10^{5}$	$2 \cdot 10^{11}$
100,000	85	10^{7}	10^{13}
1,000,000	400	$4 \cdot 10^{8}$	$4 \cdot 10^{14}$
10,000,000	2,000	$2 \cdot 10^{10}$	$2 \cdot 10^{16}$

about 200 to 400 ordinary fission processes. It might be interesting to investigate theoretically whether the highly unstable nuclear lumps would favor a larger percentage of tripartitions, and how the distribution of the fission products (especially the light one) over the various Z values would be.

A second point is whether it is possible to understand from the supernova picture of production of cosmic rays that the cosmic ray spectrum behaves like E^{-2}. In order to investigate this it would be necessary (a) to have a quantitative picture of the supernova outburst, which also would give a test for the validity of the equilibrium theory of the chemical elements (see, e.g., ter Haar, D. *Amer. J. Phys.*, 1949, **17**, 282 and *Cosmogonical problems and stellar energy*, to be published); and (b) to have a quantitative statistical picture of the fission of nuclear lumps. The aging process discussed by E. Fermi (*Phys. Rev.*, 1949, **75**, 1169) in his paper on the origin of the cosmic rays has certainly also to be taken into account. Indeed, it may well be that, as in so many other instances, a more acceptable theory will only be formed when ideas from all the different papers will have been melded togethed into one large compromise.

I should like to express my thanks to Dr. K. Lark-Horovitz for a discussion on the subject of this paper.

D. TER HAAR

Purdue University

[2] Reference in the text as mMU (milli mass units).

NEWS and Notes

Paul B. Pearson, former head of the Department of Biochemistry and Nutrition and dean of the Graduate School of Texas Agricultural and Mechanical College, has been appointed acting chief of the Biology Branch, Biology and Medicine Division of the Atomic Energy Commission. Dr. Pearson suceeds **James H. Jensen,** who has been on leave of absence from North Carolina State College and will return there as director of the Plant Pathology Division.

John M. Stalnaker, professor of psychology and former dean of students at Stanford University, has been named professor of psychology and coordinator of psychological sciences and services at Illinois Institute of Technology.

Robert F. Pitts, professor of physiology and director of the physiology laboratory at the Syracuse University Medical School since 1946, will return to the Cornell University Medical College faculty as head of the Department of Physiology and Biophysics and professor of physiology. Dr. Pitts was a staff member of Cornell Medical College from 1942 to 1946.

William F. Hester, former director of insecticide and fungicide research of the Rohm and Haas Company in Philadelphia, has been named administrator of the fellowships of Koppers Company, Inc., at the Mellon Institute. Dr. Hester will direct the work of the 98 scientists and their aides engaged in research and development work on the 13 fellowships.

A. C. Leopold, former research physiologist at the Hawaii Pineapple Company, Honolulu, has joined the staff of the Horticulture Department of Purdue University. Dr. Leopold will direct research on the flowering and nutrition of greenhouse plants.

Alfred G. Susie, chief chemist at Marbon Corporation, Gary, Indiana, has been appointed supervisor of plastics research at Armour Research Foundation of Illinois Institute of Technology. Dr. Susie will be in charge of research projects dealing with plastics in the chemistry and chemical engineering department of the foundation.

Ray Pepinsky, Alabama Polytechnic Institute, has been appointed research professor of physics at Pennsylvania State College. Dr. Pepinsky will be director of the X-Ray and Crystallography Laboratory, where he will make use of the electronic computer which he developed under contract with the Office of Naval Research.

Visitors to U. S.

Paul Rivet, director of the Musé de l'Homme, Paris, and **Claude Lévi-Strauss,** French anthropologist, were honor guests at a reception given for the members of the 29th International Congress of Americanists on September 9 in New York City.

Antonio Goubaud Carrera, of the National Indianist Institute, Guatemala City, was one of the principal speakers at the conference on Middle American Ethnology and Social Anthropology, held in New York City, September 5–12, in conjunction with the 29th International Congress of Americanists.

Visitors at the National Bureau of Standards during the week of August 29 included **D. de Klerk, K. W. Takonis,** and **C. J. Gorter,** of the University of Leiden, Holland; **G. C. Ellis,** metallurgist with the Armament Research Establishment of the Woolwich Arsenal, London, England; **N. Kurti** of the Clarendon Laboratory, Oxford, England; **Benjamin Mantel M.,** chemical engineer with the Public Works Department, Havana, Cuba; **C. Nanjudayya,** research officer, Technological Laboratory, Indian Central Cotton Committee, Bombay, India; **A. van Itterbeek,** director, Low Temperature Laboratory, University of Louvain, Belgium; and **Fredrik Dahlgren,** head of the Electrical Engineering Department, Royal Polytechnic Institute, Stockholm, Sweden.

Grants and Awards

The John Simon Guggenheim Memorial Foundation has awarded 22 Latin American fellowships, totaling $70,000, to assist Latin Americans in carrying on research and creative work in the U. S. Fields of investigation in which scientists were honored include medicine, zoology, paleontology, botany, and mathematics. The foundation awards are the twentieth in its annual series of inter-American fellowships. Last April the foundation granted 144 fellowships to citizens and permanent residents of the U. S. and Canada.

At a special convocation held on the 200th anniversary of the birthday of Goethe, the **University of Frankfurt** conferred honorary degrees on the following scientists: M.D. degree—Franz Bluntschli, professor of anatomy at the University of Bern, and Paul Weiss, professor of zoology at the University of Chicago; Ph.D. degree—Otto Hahn, professor of physics at the University of Goettingen and director of Max Planck Gesellschaft, and Ferdinand Blum, former collaborator of Paul Ehrlich.

The John Price Wetherill Medal of the Franklin Institute of the State of Pennsylvania has been awarded to Edgar Collins Bain, vice president in charge of research and technology at the Carnegie Illinois Steel Company. Dr. Bain has been honored for his research in the structure of metallic alloys and the application of the isothermal method to the study of the rates of transformation in steel.

The new $1,000 Precision Scientific Company Award in Petroleum Chemistry will be granted to Bruce H. Sage, professor of chemical engineering at the California Institute of Technology. Dr. Sage, who is also associate director of engineering and head of the explosives department at the Naval Ordnance Test Station, Inyokern, California, will receive the prize at the national meeting of the American Chemical

Society in Atlantic City, New Jersey, on September 19. The society's **$1,000 Award in Pure Chemistry** will be presented at the same time to Richard T. Arnold, professor of organic chemistry at the University of Minnesota. Dr. Arnold will be honored for his work in the mechanisms of reactions and the nature of aromatic nuclei.

The Frederick Ives Medal of the Optical Society of America has been awarded to George R. Harrison, dean of science at Massachusetts Institute of Technology. The medal will be presented at the annual meeting of the society at Buffalo in October.

The Elmer Hess Prize of the Northeastern Section of the American Urological Association has been presented to Howard T. Thompson, Buswell Fellow in the Department of Surgery of the University of Rochester School of Medicine and Dentistry, for his report on animal experiments in cancer of the bladder.

Meetings and Elections

An important discussion of legislative matters affecting science and scientists took place on Aug. 24, at the Marine Biological Laboratory, Woods Hole, Massachusetts. Howard A. Meyerhoff, Executive Secretary of the AAAS, led a meeting on the National Science Foundation and on the problems raised by the loyalty investigations of scientists.

The Report of the AAAS Special Committee on Civil Liberties of Scientists, recently approved by the AAAS Council, was summarized. Its conclusions (*Science*, Aug. 19, 1949, pp. 177–9) strongly condemn the application of security clearance and the Loyalty Order to others than those working in military research. The linkage of the problem of federal support of science and the current hysteria on clearance and loyalty was emphasized in the discussion. Scientists generally recognize that effective development of science through federal support is being threatened by the indignity and insecurity to which scientists are exposed by investigations which probe thoughts and private lives rather than specific deeds.

Detlev W. Bronk, chairman of the National Research Council, stated that the NRC is unequivocally opposed to application of clearance procedures to any scientist not working on classified projects, but will continue administering funds because some 50 present fellows, whose grants are to be renewed on October 1, might otherwise be unable to continue. According to Dr. Bronk, the failure of individual scientists and of scientific bodies to take a firm, public stand on so vital a matter of scientific and national policy already has weakened the position of the NRC.

The ensuing discussion emphasized the need for scientists and scientific organizations to become acquainted with what is happening and to take prompt and decisive action to stop the indiscriminate extension of security regulations so fatal to the free development of science. Over 100 scientists at Woods Hole affixed their names to an endorsement of the AAAS report within a few days after the discussion.

The question was also raised whether the NRC, if it were to accept administration of funds under security restrictions to individual and scientific freedom, would endanger for the sake of some 50 present AEC fellows, the long-term welfare of the nation's science. The point was raised that a flat refusal by the NRC to administer such funds might actually lead Congress to remove the restrictions rather than to abandon the fellowship program.

Dr. Bronk stated that the NRC needs the support of the body of American scientists. To obtain such support, it was proposed by participants at the meeting, (1) That the NRC institute a poll of all scientists, asking an expression of opinion regarding administration of funds where restrictions on education are involved. This poll could be held expeditiously by allocating a page in *Science* to the question with a returnable answer form. (2) That the Council inform the present AEC fellows of its opposition, on principle, to the blanket requirements of clearance; that its decision to continue administering the present fellowships is based on its unwillingness to jeopardize the stipends; and that it will not administer the fellowships unless a majority of the fellows so desire. The council should further pledge that if present fellows wish to seek stipends or positions elsewhere, it will assist them.

A suggestion to provide emergency stipends for those AEC fellows who elect not to accept renewals under the restrictions and who cannot immediately get other fellowships or positions was made. To provide for the latter, a campaign should be launched among scientists and scientific societies for a special emergency fund to which individual scientists would each pledge $5 or more. These suggested actions would demonstrate to the Congress and to the public that scientists feel strongly about the rising tide of restrictions which threaten the future of the nation's science and its welfare. That scientists are reacting to these threats is made evident by three communications appearing simultaneously in the August 19 issue of this journal. They are: (1) The report of the AAAS Committee, (2) the condemnation of the O'Mahoney rider by the AEC General Advisory Committee, and (3) a letter from Marshall Stone explaining his resignation from the NRC Committee on Post-Doctoral AEC Fellowships.

ROBERT CHAMBERS
HARRY GRUNDFEST
ROBERT HODES

A symposium on large-scale digital calculating machinery will be held September 13–16 at Harvard University under the joint sponsorship of the university and the U. S. Navy Bureau of Ordnance. The purpose of the meeting is to consider use of the machines for solving problems in the social sciences, physiology, and psychology. These problems will be discussed at the final session of the meeting by specialists in the human and social sciences. Other sessions, which will be attended by scientists, government officials, and businessmen, will cover the entire field of these machines.

A symposium on brucellosis will be held September 22–23, under the joint sponsorship of the National In-

stitute of Health, Bureau of Animal Industry, and National Research Council. Twenty-four papers will be presented at the five sessions to be held in Wilson Hall, Administration Building, National Institutes of Health, Bethesda, Maryland. Morning sessions will begin at 9:30, afternoon sessions at 1:30, and the evening session, September 22, at 8:00. Printed programs will be available in advance of the meeting. C. L. Larson, of the institutes' Laboratory of Infectious Diseases, and C. K. Mingle, of the Department of Agriculture's Tuberculosis and Brucellosis Eradication Division, are in charge of the program. Preliminary plans have been made to publish the papers in a new symposium series sponsored by the AAAS and the National Institutes of Health.

The Society of Rheology will hold its 20th Annual Meeting in New York City on November 4–5, at the Hotel New Yorker. Eighteen papers on the flow and deformation of matter will be presented. Non-members are invited to attend. Programs may be obtained in advance of the meeting by writing to Earl K. Fischer, Secretary-Treasurer, 107 Washington Avenue, Charlottesville, Virginia.

The American Society for Pharmacology and Experimental Therapeutics will hold its first interim meeting in Indianapolis, November 17–19. The scientific sessions will be held at the Indiana University Medical Center.

The Roscoe B. Jackson Memorial Laboratory has appointed Leslie C. Dunn, head of the Genetics Department of Columbia University, as president of its new board of scientific directors. James B. Murphy, head of the Cancer Research Department of the Rockefeller Institute, was chosen vice president. Members of the board include Clarence C. Little, director of the laboratory; Frank Beach, professor of psychology at Yale University; Homer Smith, professor of physiology at New York University; Merle Tuve, physics professor at Johns Hopkins University; Edwin B. Wilson, vice president of the National Academy of Sciences; and Sewall Wright, professor of genetics at the University of Chicago.

Deaths

Percy Edward Newberry, 80, Egyptologist, died August 7 at his home in Surrey, England. Professor Newberry was professor of ancient Egyptian history and archaeology at Cairo University from 1929 to 1933, and a former president of the Anthropological Section of the British Association for the Advancement of Science.

Walter A. Hynes, 52, president of the Metropolitan Microchemical Society and professor of analytical chemistry at Fordham University, died of a heart attack August 21 at St. Joseph's Hospital, Yonkers, New York.

Sir Frederick William Moore, 91, Irish botanist, died in Dublin August 24. Sir Frederick was a former president of the Royal Zoological Society of Ireland, and Keeper of the Royal Botanic Gardens, Glasnevin, Dublin, from 1879 to 1922.

Edwin B. Powers, 69, head of the University of Tennessee Department of Zoology for 25 years, died August 26 at Knoxville. Dr. Powers was an expert on salmon migration and fish physiology.

Boris Krichesky, 45, associate professor and chairman of the Department of Zoology, University of California, died of a heart attack on August 28th while vacationing in Oregon. Dr. Krichesky contributed extensively to the field of endocrinology.

A survey of medical and hospital care has been initiated by Brookings Institution. The project is the first to attempt to include all sources of health services and facilities. It is estimated that the study will be completed in two years by a full-time staff of eight, with the participation of specialists in various fields who will be called in as consultants. The cooperation of national professional societies, labor organizations, insurance companies, governmental agencies (federal, state, and local), industrial health organizations, farm groups, and other groups is being solicited.

Present plans call for publication of findings in two volumes: the first, a comprehensive and statistical report which will make available data on the extent of medical care and provisions for meeting the cost through insurance or prepayment plans, or through public services or private philanthropy; the second, based upon facts presented in Volume I, would evaluate the plans now in operation and those proposed.

The American Society of Human Genetics, which was organized about a year ago, will start to publish in October a journal pertaining to research in human genetics. The publication is called *The American Journal of Human Genetics,* and will be edited by C. W. Cotterman, Heredity Clinic, University of Michigan, Ann Arbor. Manuscripts for consideration should be sent to Dr. Cotterman. The journal will appear in annual volumes of four issues each at $8.00 per volume. Subscriptions should be addressed to the secretary of the society, Herluf H. Strandskov, Department of Zoology, University of Chicago, Chicago 37.

The National Bureau of Standards announces the following recent additions to the series of 169 compounds now available as standard samples of hydrocarbons for calibrating analytical instruments and apparatus in the research, development, and analytical laboratories of the petroleum, rubber, chemical, and allied industries: n-tridecane, cis-2-hexene, 4,4-dimethyl-trans-2-pentene, 1,2,3,5-tetramethylbenzene, 1-methyl-4-tert-butylbenzene, naphthalene, and 2-methylnaphthalene. A complete list of samples may be obtained from the National Bureau of Standards, Washington 25, D. C.

The National Geographic Society will sponsor a field survey of the scarlet ibis in the hinterlands of Venezuela. Paul A. Zahl, biologist and ornithologist of New York City,

will direct the expedition, which will study the nesting practices, habitat, and migration of the scarlet ibis and other bird life of the area. Dr. Zahl hopes to locate colonies of the scarlet ibis in rookeries deep in the flooded llanos of Venezuela's State of Apure, which can be reached only by small boat or horseback. The birds are reported to have sought refuge with herons, other ibis varieties, and possibly spoonbills.

Dr. Zahl will make his headquarters in San Fernando, where he will be joined by native helpers. The government of Venezuela will cooperate with him to further the work of the project. The expedition will be assisted by William Phelps, resident associate in Caracas of the American Museum of Natural History.

The new system of electrical measurement using absolute units, adopted by the International Conference of Weights and Measures and officially instituted January 1, 1948, is described in a new booklet, Circular C475, ***Establishment and Maintenance of the Electrical Units,*** published by the National Bureau of Standards and available at 25 cents a copy from the U. S. Government Printing Office, Washington 25, D. C. The booklet gives an account of the working, history, and maintenance of the international system of electrical units. Also described are the methods used in the measurements that now form the basis for the absolute units, in which all certifications for standards and instruments are given by the National Bureau of Standards.

The Registry of Rare Chemicals, 35 West 33rd Street, Chicago 16, Illinois, lists the following wanted chemicals: 1,4-dihydropyrazine-2,3-dione, 1,2-dihydropyridazine-3,4-dione, 1,2-dihydropyridazine-3,6-dione, *l*-mannose, *l*-galactose, naringenin, 2-methyl-3-hydroxy-γ-pyrone, phosphorylthiocholine, phosphorylcholine, coniferyl aldehyde, imperatorin, 6-ketoprogesterone, 2-methyl-5-hydroxypropiophenone, 2-methyl-3-nitropropiophenone, 2-methyl-5-aminopropiophenone, sulfanylthiourea, phloretin, cyclobutane, cyanogen, and 2-thio-4-aminopyrimidine.

Make Plans for—

American Society of Photogrammetry, regional meeting, October 3–4, Denver, Colorado.

American Dietetic Association, 32nd annual meeting, October 11–14, Denver, Colorado.

American Association of Petroleum Geologists, October 12–15, Biloxi, Mississippi.

American Dental Association, October 17–21, San Francisco.

Symposium on small angle X-ray scattering, October 21–22, University of Missouri, Columbia.

National Academy of Sciences, autumn meeting, October 24–26, University of Rochester, New York.

Optical Society of America, 34th annual meeting, October 27–29, Hotel Statler, Buffalo, New York.

Recently Received—

Journal of the Council for Scientific and Industrial Research, Commonwealth of Australia. (Quarterly publication.) Direct inquiries to J. J. Gourley, Govt. Printer, Melbourne, Australia.

Study of the Interrelationships of Psychological and Physiological Measures on Submarine Enlisted Candidates by Ellsworth B. Cook and Robert J. Wherry. Issued by Medical Research Laboratory, U. S. Naval Submarine Base, New London, Conn.

Cochise and Mogollon Sites, Pine Lawn Valley, Western New Mexico, by Paul S. Martin, John B. Rinaldo, and Ernst Antevs. (Fieldiana: Anthropology, Vol. 38, No. 1.) Issued by Chicago Natural History Museum, Chicago, Ill. $3.50.

Table of Sines and Cosines to Fifteen Decimal Places at Hundredths of a Degree. (National Bureau of Standards, Applied Mathematics Series No. 5, 1949.) Available from Supt. of Documents, U. S. Govt. Prntng. Office, Washington 25, D. C. at 40 cents.

El Aliso (series of papers on the native plants of California), Vol. 2, #1, including "A Long Term Test of Seed Longevity." Rancho Santa Ana Botanic Garden, Route 3, Anaheim, Calif. $5.00 per volume.

List of Scientific Papers Published in the Middle-East, May 1949 issue. Unesco, Science Cooperation Office—Middle-East, Cairo, Egypt.

The Terena and the Caduveo of Southern Mato Grosso, Brazil by Kalervo Oberg. (Smithsonian Institution, Institute of Social Anthropology, Publ. No. 9, 1949.) Order from Supt. of Documents, U. S. Govt. Prntng. Office, Washington 25, D. C. Price 60 cents.

Guide to the Collection of Rocks in the British Museum. (2nd ed.) Order from British Museum (Natural History), London, S. W. 7. One shilling.

Third Annual Report of the South African Council for Scientific and Industrial Research. Printed by Cape Times, Ltd., Cape Town, South Africa.

The deadline for the receipt of nominations by fellows of the AAAS for the **Theobald Smith Award in Medical Sciences,** established in 1936 by Eli Lilly and Company, has been extended to *October 30.* For the conditions of this annual award, which consists of $1,000, a bronze medal, and travel expenses up to $150, see *Science,* July 15, p. 80. Nominations should be sent to Dr. Gordon K. Moe, secretary of Section N, Medical School, University of Michigan, during September, and to Dr. Malcolm H. Soule, chairman of the Award Committee, same address, during October.

Entries in the **Annual International Photography-in-Science Salon,** sponsored jointly by *The Scientific Monthly* and the Smithsonian Institution, will be accepted by the Editor, *The Scientific Monthly,* 1515 Massachusetts Ave, N.W., Washington 5, D. C., up to the date of judging, *September 24, 1949.*